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LUNAR CHANGES DURING THE ECLIPSE OF DECEMBER 16, 1899.

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FOR POPULAR ASTRONOMY.

The Moon rose at Cambridge at about $9^h\ 30^m$ G. M. T. The first contact of the shadow was at $11^h\ 45^m$, the middle of the eclipse at $13^h\ 26^m$, and the last contact at $15^h\ 07^m$. Magnitude of the eclipse according to the American ephemeris 0.996. My observations with the 15 inch equatorial were confined to a study of four formations, namely, Riccioli, Schröter's Valley, Linné, and the large irregular plain west of Webb. These observations were made with the view of determining if any alterations took place in these objects due to their passage through the Earth's shadow. These same formations had been examined at the time of the eclipse of December 27, 1898, with the same view in mind, as detailed in the *Harvard Observatory Annals*, Vol. XXXII, page 256. On that occasion changes had been suspected in Linné and Webb, but it was felt that the observations required confirmation.

On the present occasion a light veil of cirrus clouds covered the sky, rendering the definition remarkably good for this locality. Before the eclipse the seeing was 6 upon the standard scale, afterwards it was 8. Since the libration carried Riccioli far towards the eastern limb, it was hoped, for reasons given in the article above mentioned, that some evidence of change due to the eclipse might be detected in it. None could be found, however, nor was any alteration observed in Schröter's Valley, nor in the plain near Webb.

At the time of the eclipse of 1898 the seeing was very bad at Cambridge, but fortunately I had requested Mr. Douglass, who was then at Flagstaff, to measure the north and south diameter of Linné upon the five nights of December 25, 26, 27, 28 and 29. He did so, and as a result wrote me "I should say that the crater was smaller on the 27th than on the other four nights, but exhibited a slight increase of size for thirty minutes after totality." That the crater, or more strictly speaking the white

spot surrounding it, would be smaller on the 27th than on the other four dates was what I had expected, from observations already made at Cambridge, but what the effect of the eclipse would be upon it was at that time only a matter of conjecture. However, the change was what I had supposed would take place, although Mr. Douglass was at the time unaware of that fact.

During the present eclipse especial pains were taken to repeat these measures with the greatest care possible. The shadow of the Earth reached Linné at $12^h\ 17^m$ and left it at $14^h\ 46^m$, duration of obscuration $2^h\ 29^m$. The magnifying power employed was 550 diameters. The white spot was slightly elliptical, the position angle of its major axis being 82° with regard to the Earth's meridian. The ellipticity as measured by the scale of ellipticities was 1.12 before the eclipse, and 1.10 afterwards, these numbers representing the ratio of the major to the minor axis. The following measures of the minor axis were secured. The first two columns of the table give the date and Greenwich Mean Time of the observations, the third gives the number of days since the Sun rose upon Linné, the fourth the quality of the seeing, the fifth the mean difference of the six micrometer readings constituting a single observation, the sixth the residuals, and the seventh the average deviation. The eighth column gives the micrometer reading corrected for the breadth of the threads, the ninth its reduction to arc, and the last the final value, after applying the subjective correction, which in my case amounts to 0″.25.

DIAMETER OF LINNÉ.

Date.	G. M. T.		Days.	S.	Microm.	Residuals.	Av. dev.	Thread.	Arc.	Corr.
1899 d	h	m							″	″
Dec. 13	10	26	5.0	—	0.387	*.003*, .000, .003	0.002	0.340	2.56	2.81
15	11	00	7.1	4	.373	.008, *.012*, .004	.008	.326	2.46	2.71
15	11	34	7.1	5	.350	.002, .006, *.007*	.005	.303	2.29	2.54
16	11	32	8.1	6	.313	*.002*, *.004*, .007	.004	.266	2.01	2.26
16	11	56	8.1	6.5	.280	*.015*, .002, .014	.010	.233	1.76	2.01
16	12	02	8.1	6.5	.277	*.003*, *.005*, .009	.006	.230	1.73	1.98
16	12	17	8.1	—		Linné obscured.		——	——	——
16	4	46	8.2	—		Linné emerged.		——	——	——
16	14	54	8.2	8	.293	*.001*, *.005*, .005	.004	.246	1.86	2.11
16	15	03	8.2	8	.275	.000, .004, *.005*	.003	.228	1.72	1.97
16	15	44	8.2	8	.270	*.006*, .002, .003	.004	.223	1.68	1.93

As shown in the volume of the Annals above mentioned, the diameter of the white spot about Linné two days after sunrise is 4″, by the eighth day after sunrise it reaches a minimum, and is re-

duced to 2″, and two days before sunset it has increased to about 3″.5. It will be noticed in the above table the first three measures made upon the fifth and seventh days are larger than any of the others.

The first reading made upon the date of the eclipse as compared with its two successors made immediately afterwards, is unaccountably large. This is probably due in part to the inferior seeing, which would have this effect, and in part to accidental errors. Omitting it from consideration for the present, we find that before the eclipse the mean diameter of the spot was 2″.00, immediately after the eclipse it was 2″.11, and soon after that it was reduced to 1″.95. The mean of the first two and the last two is 1″.97, which, subtracted from the reading made immediately after the eclipse is 0″.14, corresponding to 0.17 miles or 0.26 kilometers. That is to say, owing to the eclipse, the white spot surrounding Linné apparently increased in diameter by about one-sixth of a mile. Including the rejected measure, the mean of the five readings, to be compared with that taken immediately after the eclipse is 2″.03, giving an enlargement due to the eclipse of 0″.08.

Although these results certainly cannot be called conclusive, still, they tend to confirm those already obtained by Mr. Douglass during the previous year, both in the fact of the existence of an enlargement, and also in the observation that the effect is of short duration; and perhaps that is all that can be expected, when we consider how small a quantity is involved. There seems to be a strong reason to believe, as has been already stated, that the size of Linné increases as the Sun approaches its horizon, and if this is so, it certainly seems natural to suppose that it should increase in size if the Sun's light were withdrawn from it altogether. At all events that is the effect which has been observed at two different eclipses, by two different observers, one of whom had no personal bias, since he did not know what to expect.

HARVARD COLLEGE OBSERVATORY,
December 24, 1899.

CONCERNING THE EARTH'S MOTIONS.

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For Popular Astronomy.

The expression, so often used in everyday conversation, "Immovable as the Earth;" is after all, only relatively true, and could not be accepted for a moment, as a scientific statement of fact. Equally open to a little friendly criticism, in this regard, are the well known words, in which Juliet adjures her lover: "O swear not by the Moon, the inconstant Moon, that nightly changes in her circled orb, lest that thy love prove likewise variable." The Moon is, however, not more inconstant than the very globe upon which Juliet stood. Investigation by astronomers has revealed the fact that the Earth is circling and swinging and changing its course in a manner that is well nigh baffling to the understanding.

In the first place our Earth revolves upon its axis, as any school boy knows, just as an orange may be made to rotate round a knitting needle, thrust through its volume. It is, of course, this motion which gives us the endless succession of day and night. If the equator be regarded as a huge wheel, it makes one complete revolution in about 23 hours and 56 minutes. During this period of time, the Sun has moved forward in its course, over a million miles, so that the Earth requires to continue its rotations for 4 minutes longer, in order that it may bring the same meridian, under the central beam of light from the Sun, which shone on it, at the beginning of any one of its rotations. It thus makes the period of rotation 24 hours for each day and night. The period of 23 hours 56 minutes is called the *sidereal* day; and the 24-hour period is the solar day.

Passing on to the annual motion of the Earth round the Sun, we find that this revolution is the one which produces the seasons, in regular succession. The path or orbit of the Earth round the Sun follows a line, which is simply a vast ellipse. The major axis of this ellipse, is given, by some authorities, so as to place the Sun, approximately, three and a half millions miles, nearer one end of the ellipse than the other.

It may be advantageous, just here, to glance at one of the properties common to all ellipses. There are, in every true ellipse, two points, situated on the greater diameter, called foci. An ellipse has been shortly defined, as a plane curve, such that the sum of the distances from any point of the curve, to the two fixed

points, is a constant. It may be added, that the two foci, are, of course, always separated by a line of constant length.

The Earth, then, swings round the Sun in a path called an ellipse, the Sun occupying one of the foci. As the Earth swings past the Sun, at the nearer end, one would expect that at this portion of its path, it would receive more heat, than when at the farther end, as it is then about three and a half millions of miles nearer the great source of heat and light. Paradoxical as it may seem, northern countries experience, at this nearer approach to the Sun, their winter season. At the more distant end of the orbit these northern lands enjoy their summer weather. The reason for this lies in the fact that the axis of the Earth is tilted, and makes an angle with the plane of its own orbit of about $66\frac{1}{2}°$. The consequence of this axial tilt is, that when the Earth is closer to the Sun, the rays of heat fall more obliquely on the northern hemisphere, than they do when the Earth assumes its more distant position. The rapidity of the Earth's motion about the Sun has been estimated at about 19 miles per second.

Glancing now, very briefly at another, and more complex motion of our planet, one may say that the above holds good on the assumption that the inclined axis of the Earth always moves parallel to itself, during the entire cycle round the Sun. Though the axis does approach very close to absolute parallelism, all the way round, yet, strictly speaking, it is not so. The tilt of the axis, and the Earth's peculiar shape give rise to a curious and interesting motion, which astronomers have called the *precession of the equinoxes*.

The shape of the Earth is not that of a perfect sphere. It is in reality that of an oblate spheroid, or in other words, it is slightly flattened at the poles and bulges out in the neighborhood of the equator. The polar diameter of the Earth is somewhere about 26 miles shorter than its equatorial diameter. This equatorial protuberance, is at times, above and again below, the line joining the centres of Earth and Sun, owing to the tilt of the axis of the former. The effort of the Sun's attraction, acting along the line of centres, on this protuberant mass, tends to draw the Earth into such a position that the axis of the latter shall be perpendicular to the plane of its orbit about the Sun. This effort, directed upon a rapidly rotating body, like our Earth, causes each pole to describe a circle, traced out in the heavens, in a manner similar to that of a spinning top, whose axis revolves slowly, in a cone. The revolution of the Earth's axis round this circle, which, if the poles be supposed to be prolonged until they

reach the stars, above and below the Earth, is a very slow one indeed, and in marked contrast to the rapid diurnal rotation and annual rates of revolution. The complete revolution of the axis, or the precession of the equinoxes, requires a period of no less than 25,827 years.

From this it will be evident that the true polar point in the heavens is slowly and gradually shifting its place among the stars. The star in the northern heavens which we know as Polaris, or the Pole Star, is only a close approximation to the true north point. No one point, therefore, remains permanently as our celestial pole.

It has been calculated by competent authorities, and found, that at the date of the construction of the Great Pyramid of Egypt, in the year 2170 B. C., the pole star of that remote epoch was the first star in the Dragon, more correctly called, α Draconis. At the present time α Ursæ Minoris, or the brightest star in the Little Bear, is the nearest observable point to our true north, and is in more than name, the North Star. In the southern celestial hemisphere, there is no conspicuous star to mark the polar point. The precession of the equinoxes is so called because the equinoxial points on the Earth's orbit revolve slowly around, with the circling poles.

In considering this motion, one is compelled to notice, the modification of it, which is effected through the agency of the Moon's attraction. This modification is called *nutation*, or the nodding of the pole. The path of the Moon is inclined to that of the Earth at an angle of about 5°, and her attraction when above and below the protuberance at our equator, is able to modify the lines traced by the poles, on the heavens, due to the Sun's attraction. The Moon's attractive force, though much less than the Sun's, by reason of her inferiority of mass, is yet very considerable, owing to her comparative proximity to our planet. By the delicate balancing of her power with that of the Sun, it is found that she is able to compel the otherwise circular line, traced by our poles on the heavens, to assume a sinuous form. The deviation from the circle which the Sun would cause our pole to trace, passes as much outside it as it does within, so that the resulting figure is really a scalloped circle, if one may so say; forming an exquisitely beautiful and sinuous line. The period required to make one "nod" in the pole's course is about $18\frac{2}{3}$ years. The motion, or rather, modification of motion which we call *nutation*, effects a series of slight undulations in the otherwise theoretical circle, traced by the pole in its "precession."

Next in order comes that motion of the Earth called the *advance of the apsides*. In order to properly consider it, we must here go back to our great ellipse or path of the Earth around the Sun. The apsides are the two points on this ellipse having, respectively the greatest and least distance from the Sun. They are, in fact the ends of the major diameter of the ellipse. When at either of these points, the Earth is said to be, as the case may be, in *perihelion*, when near the Sun, and in *aphelion*, when away from the Sun. These two points together with the whole ellipse or Earth path, move slowly forward in the direction of the Earth's motion.

The Earth revolves round the Sun in its diurnal motion from west to east, turning upon its axis, just as if it were being rolled over and over, on the outer surface of the Sun. In its annual motion round the central luminary, it moves in exactly the same direction, as if rolled over the Sun's surface. In the same direction also the apsides advance. This motion is caused by the attraction of Jupiter, and the other planets. It amounts to about 1° 23′ per century, so that in about 26,024 years, the advancing apsides would complete one cycle. When computed with reference to time, we find that there is a difference in the length of the year, as measured by the advance of the apsides and that of the sidereal year. This latter is the time required by the Earth, leaving any point in the heavens, and returning to it again. The year measured by this apsidal motion is 4 minutes and 39 seconds longer than the sidereal year, which latter is 365 days, 6 hours, 9 minutes and 10 seconds.

Another modification of the Earth's motion is caused by the *tilting or swaying of the ecliptic*. This is also due to the attraction of our giant neighbor, Jupiter, and his fellow planets. The ecliptic is the name given to the plane of the Earth's orbit. It may be supposed that this plane is extended outward in all directions until its edges touch the fixed stars, exactly like the surface of a level liquid, with the Earth floating, half immersed in it. The Earth's axis stands, as has been said above, at an angle of about 66½° to the ecliptic and it therefore makes the complementary angle of 23½° with a line standing perpendicular to the ecliptic. The ecliptic does not, however, lie motionless like the surface of a level liquid; but is moved up and down, or tilted about a line joining the equinoxial points, just as a table might be tilted up at one end, and down at the other, about a line drawn straight across it, in the middle, from side to side. This tilting up and down, of the ecliptic, will necessarily alter the angles 66½° and 23½° just given. The limits of the tilting

motion are from 23° 53′, with the perpendicular line, to 22° 54′, or through an angle of *59′. In the year 2000 B. C. it had the former greater angle, and it is predicted that somewhere about 6000 A. D. the lesser limiting angle will be reached. At the present time the angle is decreasing; though it is very close to 23½°.

The seventh motion, or rather variation of motion in the Earth's course are its *perturbations*. This term is applied to the slight alterations in the elliptic form of the Earth-path, about the Sun. It consists, at one time of a flattening of the curve of the orbit, and at another, of an increase in the degree of curvature as the Earth approaches or recedes from its planetary neighbors. These perturbations can be calculated before hand for each case.

The eighth and last motion of our Earth is through space, together with the Sun and the whole of our solar system. This motion, as far as can be judged up to the present time, is in an apparently straight line. It is in the direction of the star known as π Herculis. The rate of advance along this line is at the prodigious speed of 1,296,000 miles per day. The apparently straight line upon which the Earth, Sun and planets are traveling, has been held by some to be really a curve of great magnitude, having for its centre, η Tauri, more familiarly known as Alcyone—the brightest star in the Pleiades.

Briefly to recapitulate:—We have traced in merest outline five proper motions of the Earth, viz: The diurnal, the annual, the precession of the equinoxes, the advance of the apsides, and the motion through space. The modifications of motion, if they may be so called, appear to be three in number: nutation, the perturbations and the tilting of the ecliptic. This division is suggested as an easy method of classification, though the reader may prefer, with perfect propriety, to alter the classification for himself. It is, however, a wonderfully complex picture presented by our Earth, as it spins, and circles, nods and sways, rolls and rushes with terrific speed, on through space; never in reality passing through or near the same point again, once it has quitted it. It moves onward with resistless sweep, majestically, without jar or tremor of motion. With no hint of its rapid flight, it hastens on, to its appointed goal, working out its destiny in the appointed way, fulfilling as it goes, the inspired words which tell us that "while the Earth remaineth, seed time "and harvest, and cold and heat, and summer and winter, and "day and night shall not cease."

* Professor Young, on the authority of J. Herschel, gives the lower limit as 23¼° and the variation not to exceed 1° 20′ from the mean.—Ed.

WORK OF THE BRITISH ASTRONOMICAL ASSOCIATION.*

Roughly, our members may be divided into three classes, viz.: —First, the professional astronomers, connected with established Observatories, and having at their disposal, more or less ample instrumental equipment. Second, amateurs having instruments fitted for serious work and possessing, moreover, a fair amount of experience in the use of such instruments. And third, members who are students of astronomy, but who are either not possessors of instruments at all, or who have not facilities for observational work of an original kind. This third class may possibly be advantageously subdivided as I shall indicate later on.

As regards the first class, the professional astronomers, it is, I am sure, a great satisfaction to us all that we have been able to enroll so many of them in our ranks. A reference to our list of members will show that it includes professional astronomers in nearly every civilized country, men whose names are household words, and the history of whose work constitutes to a great extent the history of the recent progress of our science. It is impossible to overrate the value to our association of the collaboration of these professional astronomers. Their contributions to our publications may be comparatively few, for, as a rule, the accounts of their researches are, almost of necessity, issued through other channels; but we are indebted to them for some very valuable papers, while we have constantly benefitted by their presence at our meetings and by their aid in various ways. Without them the status of our association would certainly not be what it now is.

Next, as to the second class, that consisting of amateurs possessing more or less excellent instrumental equipments. It is this class which has formed the backbone of our observing sections, and to it is due the bulk of the original work which has been recorded in the publications of the association. In the admirable address delivered from this chair last year by our valued Vice-President, Mr. Wesley, special reference was made to the organization of our observing sections, and to the excellent work which those sections have done and are still doing. It will be quite unnecessary for me to go again over the ground which Mr. Wesley covered so thoroughly, but I do wish to strongly endorse the views which he expressed as to the value of the feature which these observing sections have formed in our organization, and as

* Extract from the Presidential Address, before the British Astronomical Association delivered Oct. 25, 1899, W. H. Maw, President.

to the great debt we owe to the directors by whom these sections have been controlled. Unfortunately we have to mourn the loss during the past year of one of the most valued of these directors, Miss Brown, but if anything could console us for this loss, it is the knowledge that the work which she so ably inaugurated, and which she carried on until the last with such conspicuous ability and enthusiasm, will be continued with the most conscientious thoroughness under the new director, Farther Cortie.

It is satisfactory to know that this second class of our members upon whom we depend so much for original work, is an ever growing one, while year by year it is becoming possessed of more powerful and more perfect instruments. And this brings me to a point on which I wish to say a few words, namely, the influence of the large telescopes, with which some of our more important Observatories are now provided, on the usefulness of the work of amateur observers. In considering this point it must be borne in mind that the great telescopes of the present day are of a very different class from the giant instruments of the past. The great reflectors of Herschel, of Lassell, and of Rosse were all instruments made and used by amateur astronomers, and although they possessed great light-grasp and did some admirable work they were, owing largely to the nature of their mountings, utterly unfitted for the class of observations on which the large telescopes of the present day are chiefly employed. The 36-in. and 60-in. reflectors of Dr. Common may, perhaps, be regarded as the latest of this older class of large telescopes, although it would probably be more just to consider Dr. Common's instruments as forming a connecting link between the giants of the past and present.

In the case of such large refractors as those at Pulkowa, at Washington, at Vienna, at Mount Hamilton, at Nice, at the Yerkes Observatory, and at Greenwich the cost of the telescope itself is but a small portion of the total outlay incurred. Not only must such an instrument be thoroughly well mounted to fit it for modern research work, but it must be protected by a well constructed dome, and in order that every moment of good seeing may be utilized, provision should be made for effecting all movements of both telescope, and dome with the least possible amount of labor to the observer using the instrument. How perfectly this can be done is well shown by the great Yerkes refractor, which, notwithstanding its enormous size and weight, can, with its dome, be so readily handled by the electric motors with which it is provided, that it can be—and is—efficiently used by a single

observer through a whole night, without any assistance whatever. It is satisfactory to know that two of our own members, Messrs. Warner and Swasey, were responsible for both the design and construction of this admirably perfect mounting, while the rising floor, which forms such an important feature in the equipment of both the Yerkes and Lick Observatories, and contributes so much to the convenient use of these large telescopes, is the invention of another of our members, Sir Howard Grubb.

But by the time a refractor of this kind has been erected and equipped the outlay upon it will have become so large, that it would be utter folly to use the instrument for work other than that for which its great power renders it specially fitted. The result of this is that our modern giant telescopes are, with few exceptions, employed, not in doing work which was formerly done by smaller instruments, but in doing work which formerly could not be done at all. Such for instance, is the bulk of stellar spectroscopic work including determinations of velocity in the line of sight, the measurement of close double stars, the spectroscopic examination of nebulæ, the discovery of new planetary satellites, and similar matters. We see, therefore, that the establishment of these powerful telescopes has been accompanied by the development of new fields of research, and that the work which was formerly done—and can still be well done—by instruments of moderate size, has not been reduced. On the other hand, many professional astronomers have withdrawn from the work which they formerly did with the instruments then available, and they have thus left to amateur observers the continuance of their former labors.

We thus see that there is ample work for the members forming our observing sections and that such work, if faithfully carried out and recorded with judgment and discrimination, is calculated to be of great and permanent value.

This brings me to a somewhat delicate point on which it is, I think, my duty to say a few words:—I mean the character of the reports of our observing sections. Now the report of a section may be of two kinds, namely, it may be a simple record of all the work done by the members of that section; or it may be a digest of the facts which the labors of the section have elicited. A report of the first kind possesses the advantage that it gives full credit for the work of individual observers, and so far acts as an encouragement to further efforts; but one is apt to rise from the perusal of such a report with a very confused idea of what it all means, and as a document for reference it

certainly leaves much to be desired. A report of the second kind, on the other hand, if carefully drawn up by an observer having special experience in the matters dealt with, such as the director of a section naturally possesses, is a work not merely of great present interest, but of permanent value, and adds materially to the standing of the society by which it is published. If our funds were abundant we might, no doubt with advantage, give our sectional reports a dual character, publishing more or less in full the records of individual observations, and adding a digest of the facts deduced by the director from those observations. In this way we should be imitating the procedure of a Royal Commission, which accompanies its report by a reprint of the evidence on which that report is founded. But, unfortunately, our funds are far from being abundant, and we are, therefore, bound to practice strict economy, and to endeavor to spend our money so that it may be of the greatest benefit to our members generally. It is thus eminently desirable that our sectional reports should be of the character of digests of facts prepared by the directors, and that the engravings should be only such as are required to illustrate these facts and render clear points which can not be so well explained verbally. I fear that the adoption of this course may lead to some disappointment of individual workers, and to the non-publication of many admirable drawings which, if our funds allowed, we should be most desirous to reproduce. I hope, however, that members of sections will see the necessity of the course I have foreshadowed, and that they will, at all events for the present, be content with a less full record of their individual work than that to which they may possibly deem they are entitled.

And this brings me to another point, namely, the mode of recording the work of our sections. While it is at present impossible for us to print anything like full records of the work of individual observers, it is eminently desirable that such records should be available for future reference. In order that this end may be conveniently attained, however, it is essential that the reports of the observers forming any section should be sent to the director in some uniform style, and written on paper of a standard size. The selection of the form of the individual reports is, of course, to a great extent a matter to be decided by the directors of sections; but I think that all directors might agree as to a uniform size and character of paper, and I would suggest ruled foolscap would be as convenient as any. Every report of an observation, however brief, should be written on paper of the

standard size, the writing being on one side only, and a broad margin being left on the left-hand side of each page for the addition of marginal notes or cross-references by the director. I happen to have had through my hands the individual reports received by more than one of our directors of sections, and I have been struck by the great amount of extra labor which is but too often thrown upon the director of a section by the varied character of the notes of observations sent to him. When such notes are contained in letters of all sizes, written on both sides of the paper, and often mixed up with other matter, one cannot wonder that the task of unearthing and digesting the facts is one which a director is not greatly inclined to undertake. On the other hand, individual notes on sheets of uniform size can be readily classified, and after the preparation of the director's reports they can be conveniently collected and preserved in pamphlet cases in our library for future reference. Altogether I would strongly urge the consideration of this point on our directors of sections.

I have now to deal with the third class of our members, namely, those who are either non-observers or who, if they observe at all, are provided with a very limited instrumental equipment. This is a very large and important class, and it may, as I have already hinted, be conveniently sub-divided into at least two sections, one comprising those who already possess a considerable knowledge of astronomy, and the other consisting of those who are more or less beginners in the study of our science. To both these sections our Association should be of considerable service, while both, on the other hand, can materially aid the objects which the Association has in view.

To our members forming the first sub-division much really useful work is open. In the first place they may render valuable aid to our observing sections. Nominally, of course, our sections should consist of actual observers, but as I have already pointed out, observations can only be estimated at their full value when carefully arranged and compared, and I see no real reason why the ranks of our observing sections should not include members who, although not observers themselves, are competent to discuss and compare the observations of others. It has to be borne in mind, too, that such discussions of observations as I am here referring to, should not be confined to the examination of new observations only; on the contrary, it should include comparisons with past published records, for it is only by such comparisons that the true lessons of many new ob-

servations can be learned. The questions of the periodicity of the changes in the markings on Jupiter is a case in point.

Such aid to the work of the observing sections as I am foreshadowing would also include the calculation of cometary and double star orbits; the preparation from the records of double star observations of lists of pairs appearing to demand special attention; the examination and comparison of records of variable stars; the examination of lunar photographs and their comparison with older charts and drawings; the comparison of old and new planetary observations, and much other work of a cognate kind. How valuable may be the aid to astronomical progress rendered by researches of this class, carried out by one who is not himself—or herself—an observer is admirably shown by the writings of one of our own members, Miss Clerke, whose books and papers we all so greatly value. Altogether, I feel certain that the collaboration of competent non-observing members would be welcomed cordially by the directors of most of our observing sections.

Then, again, there are other directions in which the class of members with whom I am now dealing can do useful work. Some may strike out original lines of mathematical or geometrical investigation, as has been done by Mr. Whitmell, whose papers contributed to our "Journal" aid us so much in realizing aspects of the solar system regarded from other planets than our own; others may take up optical matters and assist in the perfecting of our telescopes and spectroscopes, as Mr. Thorpe, while still others may afford to our hard-working editor much needed assistance in his preparation of those abstracts of foreign astronomical publications which form so valuable a feature in our "Journal." I have, however, I think, said enough to show the fact of not possessing an observatory or instrumental equipment is no bar to the accomplishment by competent members of work of real value to our Association and to astronomical science generally.

I have now finally to deal with the second section of the third of the three classes into which I have ventured to divide our members. This section, it may be remembered, consists of those who are commencing the study of astronomy. I will not call these members "learners," because that is really not a distinctive term. An astronomer devoted to his science never ceases to be a "learner" however eminent he may become; and, in fact, with the growth of knowledge comes inevitably the growth of the conviction that great as has been the progress of astronomical

discovery we have as yet only touched the fringe of that great science whose possibilities are as limitless as space itself. Using then, for the want of a better, the term "beginners" to denote the class of members of which I am now speaking I wish before concluding this address—already I fear protracted to an undue length—to offer a few remarks on the manner in which I consider that the study of astronomy can be most advantageously commenced.

In the first place, however, let me comment briefly on certain complaints—for the most part very mildly expressed—which have from time to time reached me from beginners as to the character of the contents of our publications. These complaints assume that inasmuch as the promotion of the study of astronomy is one of the chief objects of our Association, that therefore our "Journal" should be devoted largely to the explanation of elementary astronomical facts. Now this is such an untenable—and I should have thought obviously untenable—assumption, that I should not have referred to it, had I not had evidence that it is somewhat widely held, but held, I believe, unthinkingly. The proper object of our "Journal" is not to afford elementary astronomical information, which can far better be obtained from text books, but to record progress and to supplement text books by keeping our members fully informed with regard to new discoveries and current astronomical work. Such elementary information as beginners require is to be sought not in our "Journal" but in our library, while our "query box" affords a ready means of obtaining explanations on points which text books may not make clear.

I trust that the remarks which I am about to make on the commencement of the study of astronomy will not lead anyone to suppose that I in the least underrate the value of the numerous popular works on our science, or the admirably illustrated magazine articles dealing with astronomical subjects, of which so many have appeared during recent years. On the contrary, I believe such books and articles have done great good, and have, by the interest they arouse, caused many additions to be made to the ranks of amateur astronomers. But the beginner who, wishing to study astronomy, confines his attention solely to such writings as I have just referred to is much in the position of a man who thinks he can become a soldier by reading glowing accounts of hard won victories. Such a beginner, who has had his imagination stirred by the examination of beautifully reproduced photographs of comets, or nebulæ, or lunar

views, is apt to experience more or less severe disappointment when he is shown these objects through a telescope of moderate size. Not having had experience in observing, he misses much detail which even such an instrument can show, and realizing how far what he sees falls short of what he had been led to expect, he is apt to jump to the conclusion that observational astronomy, at all events, offers few attractions to those who have not at command an expensive instrumental equipment.

Now this conclusion is an utter mistake, a fact which the beginner who approaches the study of astronomy in the proper spirit will soon recognize. It has to be borne in mind that, great as are the attractions of modern astro-physical research, the real basis of our science is that which is sometimes called by way of distinction "gravitational astronomy." It has further to be borne in mind that the earlier astronomers working with instruments of a very elementary kind obtained a considerable knowledge—which was in many respects really remarkable for its approximate accuracy—as to the motion of the heavenly bodies, and as to the phenomena presented by the chief members of our solar system. Now, what was done in the olden times can be done in the present day, and I wish to prominently direct the attention of beginners to the fact that by the employment of quite simple apparatus they may make observations which will bring home to them, in a way which mere reading can never do, a knowledge of many astronomical phenomena which they will find to be, not only of immediate interest, but of great value to them in their further studies.

What I wish to urge, therefore, is, that those commencing the study of astronomy should not be content with reading only, but should work in the open air, faithfully and systematically recording their observations, however elementary these may be. I lay great stress on this latter point, because unrecorded observations have, as a rule, little educational value. The mere fact of describing in writing any observation, however simple, which has been made is of immense assistance in securing completeness and accuracy. Of course, the country offers greater facilities than towns do for this out-of-door work, but there are few towns where access cannot be had to some convenient site giving a fairly clear horizon and sufficiently free from traffic to allow of star maps being referred to without serious inconvenience. Naturally the beginner's first endeavor will be to identify the brightest stars, and trace out approximately the confines of the various constellations. Continuing this study, he will gradually acquire a

knowledge of the paths followed by the stars in their courses from rising to setting, and obtain a clear idea of the position of the apparent axis of this motion. As time goes on, he will further notice that the constellations he has identified set earlier and earlier each evening, and that other constellations previously unseen will come into view on the eastern horizon, Further, he will notice that the path followed by the Moon in her course through the sky not only differs at different parts of lunation, but varies for any given part of a lunation at different seasons of the year. As his knowledge of the sky progresses, he will be able to identify any bright planets which may be visible, and to observe their changes of position with regard to the adjacent stars, changes which he will do well to note in his sketch-book for future reference and consideration. Now the beginner who has learned these elementary facts by actual observations of the sky, and has subsequently, by the aid of his text-books, mastered the reasons for what he has observed, will have made a very fair start in the study of astronomy, and he will, I venture to think, have acquired a far keener interest in the motions of the heavenly bodies than he would have possessed if he had confined his attention solely to books, or if his open-air observations had not been of a systematic character. He will also find that by the aid of some very simple home-made instruments, such as a cross staff, a rude form of transit instrument, and other similar appliances, he will be able to make observations which serve to still more impress upon his mind the facts he has been learning. Of course, such observations must be crude and wanting in accuracy, but they will, nevertheless, be found to serve a very useful educational purpose.*

To the beginner who has taken up the study of celestial motions, an endless number of problems will suggest themselves for examination, and it will be found that the solution of these problems will afford work which is not only of great immediate interest, but will lead to the acquirement of knowledge of considerable future value.

It has been often said that "Learners should not be ashamed to ask questions." This is quite true in a certain sense, and no beginner should be ashamed to acknowledge that he has much to learn. But the practice of asking questions is not one to be advocated, except within certain strict limits. The beginner who gets

* Beginners desiring to take up the study of astronomy on the lines here advocated will derive considerable assistance from two American books recently published, viz., "A New Astronomy for Beginners," by Professor David P. Todd, and "A Laboratory Manual in Astronomy," by one of our own members, Miss Mary E. Byrd.

into a difficulty and immediately asks for aid to get out of it, is not likely to make any great progress. It is the battling with difficulties, the habit of regarding a problem from various points of view, and the practice of "getting at the bottom of things," which impresses truths and principles on the mind, and a few facts so learned are worth ten times the number acquired by the question and answer method.

The statement I have just made appears to me to apply with special force to the use of instruments. Many present have no doubt been struck, as I have, by the character of numerous queries respecting the use and adjustment of instruments which, from time to time appear in print. These questions suggest the idea that those proposing them are of opinion that scientific instruments should be made on the "You-touch-the-button-and-we-do the-rest" principle, and that their employment should require no special knowledge on the part of the user. Now this is a frame of mind which is much to be deprecated. Nothing is more essential to secure the best results with any instrument than a clear comprehension of the principles on which such instrument is constructed. It is only by the possession of such knowledge that the user of a telescope, a spectroscope, or other astronomical appliance can determine whether or not any defect in performance is due to a radical fault in such instrument or to a comparatively trivial fault in adjustment. For this reason I would thoroughly urge beginners, when they take up actual observing, to study carefully the theory of any instrument they may employ, and make themselves familiar with its principles and construction. Were this more generally done, much disappointment and loss of time would be saved, and instrument makers would be spared many unjust complaints and much worry.

I am afraid that my remarks on the section of our members which I have classed as "beginners," have run to an undesirable length, but it must be remembered that the "beginners" of to-day are those from which we shall at an early date expect work which will promote the interests and strengthen the position of our Association, and any suggestion which may aid in their training may thus possibly be regarded as excusable.

In conclusion I may quote a passage from the works of Bacon, which was written to have a wide significance, but which appears to me to apply with peculiar force to the science to which we are all devoted. Says the great philosopher:—"Knowledge "is not a couch whereon to rest a searching and restless spirit; "nor a terrace for a wandering and variable mind to walk up

"and down with a fair prospect; nor a tower of state for a "proud mind to raise itself upon; nor a fort or commanding "ground for strife and contention; nor a shop for profit or sale; "but a rich storehouse for the glory of the Creator and the re- "lief of man's estate."

THE STUDY OF ASTRONOMY. II.

W. W. PAYNE.

In the last number of this publication (p. 24) we began to say some things about the study of astronomy, as the same is now pursued. It was there pointed out that the writer believes some important changes are now being made both in regard to the method of teaching, and, in studying the elements of this branch of science. It was said that representative school men who have been occupied in teaching branches kindred to astronomy have been so interested in the so-called "laboratory methods that they have quite forgotten that elementary astronomy is a branch of general physics, and that the methods that serve well in elementary chemistry and the elements of natural philosophy must equally well apply to astronomy. Not only this, but the further and more serious complaint must be made, that these same school men in science who are offering and requiring schemes of study in the secondary schools, and strongly urging them publicly, very generally exclude from these schemes the study of elementary astronomy altogether. They do this for two reasons: The first is because they want more time for laboratory work in elementary physics and chemistry. Some are claiming that this laboratory work in elementary physics should be extended over the time of a full year continuously to cover necessary themes and to do the work as it ought to be done. But those instructing in chemistry say no to this, and claim that two-thirds of this time is ample for the work of chemistry in such schools, and that teachers of physics should be satisfied with so large a change in their favor as that which has come into practice recently.

The second reason why elementary astronomy is dropped from the courses of study in the secondary schools is because those who form these courses say the subject is too difficult for students in those schools, and, therefore those who want to study elementary astronomy should wait until they reach college. The writer of this article would never have believed that any leading super-

intendent or high school teacher in a country town would have made such a public statement as this, if he had not heard it with his own ears. Much less would he have believed that the instructors in some of our large cities should be found advocating the same thing for the same reason.

Now, certainly one of two things is plainly evident, wherever such reasoning is allowed to prevail; either the superintendents or teachers or both do not themselves know enough of elementary astronomy to teach it, or they do not know *how* to teach it. For no one who is at all observant can have failed to notice that nothing interests the old and the young alike, as much as the simple rehearsals of a little knowledge of the Moon, Sun, planets, stars and meteors. Miss Mary Proctor, of New York, is largely employed in giving public talks to children about astronomical subjects for compensation and interested adults are often found in these gatherings. We know that students of astronomy in all parts of the United States are giving familiar talks on astronomy to audiences including persons of all ages with acceptance and very general favor. Almost every week country papers published in California, Pennsylvania, Massachusetts, Iowa, Illinois, or some other states come to us with marked articles, showing that the readers of POPULAR ASTRONOMY have been setting forth some important matters of current astronomical interest for interested readers in their respective rural localities. For the same reason, viz: the popular interest in elementary themes of astronomy, associations have sprung up in the United States, Canada and England partly for the study of what people do not generally get in the secondary schools and, of course, partly for the purpose of keeping abreast with the progress of astronomy in later years.

Now, what does all this mean? To our mind it plainly means that our secondary schools, and some of our colleges and academies are not giving to the branch of elementary astronomy the attention it should receive. Our teachers are not informed as they should be. They do not generally know how to teach elementary astronomy as it should be taught.

Enough has been said to call attention to the widespread interest in the themes of elementary astronomy for all classes of people, and, also, to indicate how very far from the truth, the statement is which claims that elementary astronomy is a branch too difficult for the grasp of the students in secondary schools. If this be true, it is certainly necessary that instructors in these schools look into this matter more thoroughly, that

they prepare themselves to judge of the value of elementary astronomy as an important theme for place in their courses of study, and above all, that they prepare themselves to teach the branch in all grades of instruction, including the high school and those above it which are not entered by examination, at least, in the elementary part of the subject.

This last part of the instructor's qualification for his work is all important. We believe that the root of the difficulty which has brought about present lethargy, conscious inability and manifestly weak judgment on the part of prominent school men and instructors lies in the fact that teachers have not known how to instruct well, if they have some knowledge of the branch of elementary astronomy. We wish to offer some suggestions on ways and means to this end. This brings us to the unfinished point we were considering in our last when we found that all our space was taken. In continuing the thought of how to teach the elements of astronomy we may illustrate this in several ways. The first, because it is as simple as any, is the celestial sphere and the fixed stars. In our first volume of POPULAR ASTRONOMY is found a series of articles by Professor Winslow Upton, Director of Ladd Observatory of Brown University, Providence, R. I., who has taken great pains to write out a course of study of the constellations in a way to make it easy for any interested student or teacher to inform himself fully and well about the bright stars and the constellations that may be seen by common observers. There is no question in our mind, whether or not a teacher of elementary astronomy thould know the constellations familiarly, and the stars of the first and second and, at least, some of the third magnitude at sight. That much is so easy to learn and the information is so useful in many ways, that we need only to mention the matter, that any teacher who has not thought about it will at once see the advantages. If teachers should ask their pupils what bright stars are visible at particular hours of the early evening and at what places in the sky they may be seen, ordinary high school students would surely be interested in looking after the stars, and probably they would be anxious to learn the names of such as should attract their attention, and if the teacher can not impart this information readily and certainly, that teacher must rightly take a lower place in that student's estimation than he should hold.

Again, suppose some bright student should ask the instructor at what time Vega or Sirius passes the meridian on a given day, it ought not to be difficult for any teacher to give an approximate answer that would fully satisfy the bright student, and

also furnish the natural opportunity of saying something about the ways in which astronomers know how to get very accurate answers to all such interesting questions. This kind of thought and work, for and with students in the simplest lines of observation will certainly quicken and deepen an interest that will always make instruction easy and very delightful. Those who have tried it know that these statements are not overdrawn; such know that they are but the common and the natural results that flow from the use of natural and rational methods of study.

When the publication of POPULAR ASTRONOMY was begun a few years ago, a great deal of expense was incurred and much valuable aid was given freely from very competent sources in order to bring before teachers of astronomy in college, academy and the high school just such methods of instruction as we have have been hinting at in what has gone before. We secured the series of articles from Professor Upton who is an acknowledged authority on star-charting. He has since published an excellent star atlas neatly printed by Messrs. Ginn & Co., of Boston, Mass.

Before the Upton articles were completed we began the publication of the large colored star-charts which were reduced from the planisphere published by the Poole Brothers of Chicago in 1894, and each month a map of the constellations was presented in POPULAR ASTRONOMY, appropriate to the time, until a complete series of twelve covering an entire year had been given. Messrs. Poole Brothers, who own the plate and still have this excellent planisphere on sale, made the step of publishing these large colored star-charts possible to us, by themselves most generously incurring all the expense of reduction and the printing of the charts in colors. We have lately learned that the Poole planisphere has had considerable sale in the colleges and universities of this country and also abroad. We greatly wonder that it has not had larger sale in the colleges and academies and the leading high schools, for it is certainly a very meritorious piece of work. We have used the planisphere with elementary classes in astronomy for several years and we know of its value.

We have one hundred copies of volumes I and II of POPULAR ASTRONOMY, in pamphlet form, so as to accommodate teachers of the elements of astronomy who may wish to try the plan suggested above in regard to this one theme, the celestial sphere and the constellations. These volumes are selling for $2.50 when whole sets are furnished. In order to induce teachers to try this plan we will sell them to teachers, and teachers only, for one dol-

lar each, one or both, as long as they last. We have made a fuller and more complete statement in one of our advertising pages of this number.

Those schools that are provided with a good field glass or a small telescope may do some interesting work in the study of the Moon. In this the most useful guide we know of is the map of the Moon recently published by the Poole Brothers of Chicago. Great care and skill have been used in the engraving of this map to get its many different features related in a scale that should give the most correct impression of the lunar surface as a whole, and also, to represent the individual markings in such way, as to satisfy good photographs and visual observations as far as possible. We think no one can understand the difficulty of such an undertaking who has not tried it. We personally know the artist, Mr. J. A. Colas, of Chicago, and we are fully informed of the labor expended on the plate before satisfactory results could be reached; having before him for imitation for a long time the best photographs of the Moon that could be obtained, in order to transfer to the plate the delicate transition of shade that was shown in the photographs, and, as far as possible to soften the errors of contrast in light and dark shading which always appear even in the best photographs.

Knowing all this and more about the way in which the Poole Map of the Moon was made, our readers will not wonder that we became interested greatly in this piece of astronomical work as a means of illustration in teaching the elements of astronomy to classes in Carleton College. Whether we use the field glass, the small telescope or the large one, this excellent map of the Moon is our reference and the little pamphlet of twenty-four pages that goes with it, as a key to its numbers, contains a catalogue of more markings than those given by Webb or Proctor. The plan is to look at the Moon with the instrument, use the guide and the map as references for name and location and such other facts as are cited or easily obtained from other sources if desired.

Our experience is that students become so interested in study and observation in this way that they want, and find time for, more hours of study of particular themes than is required. It is never necessary to urge requirements in order to secure work enough to make what is sometimes called a passing grade in the study, as college language sometimes puts it.

Next time we want to say something about other simple apparatus to aid in illustrative study of the elements of astronomy.

THE CORONA OF THE SUN AS SEEN BY E. MILLER, MAY 3d, 1899, THERE BEING NO ECLIPSE OF THE SUN.

E. MILLER,

FOR POPULAR ASTRONOMY.

Professor C. A. Young, perhaps the most competent authority upon solar phenomena, writing about the Sun's corona, says—"We must evidently wait awhile for the solution of the problems presented by the beautiful phenomenon. Possibly the time may come when some new contrivance may enable us to see and study the corona in ordinary daylight, as we now do the prominences. The spectroscope, indeed, will not accomplish the purpose, since the rays and streamers of the corona give a continuous spectrum; but it would be rash to say that no means will ever be found for bringing out the structures around the Sun which are hidden by the glare of our atmosphere. Unless something like this can be done, the progress of our knowledge must be very slow, for the corona is visible only about eight days in a century, in the aggregate, and then only over narrow stripes on the Earth's surface, and but from one to five minutes at a time by any one observer."

Sir Robert S. Ball, in "The Story of the Sun," says—"Such is an outline of the facts known to us with regard to the corona; and it must be admitted that our information is at present of a somewhat meagre description. We can only hope that the attempts to photograph the corona without having to wait for a total eclipse may ultimately prove successful.

Doubtless many of our perplexities would vanish if a series of observations taken at brief intervals were certainly available. We might then expect to gain information regarding the changes in the corona, which it seems absolutely certain are in progress. We might expect, too, that some satisfactory evidence might be forthcoming as to the actual character of the material to which the coronal light is due."

In Langley's splendid book, "The New Astronomy," we read—"Outside all is the strange shape which represents the mysterious corona, seen by the naked eye in a total eclipse, but at all other times invisible even to telescope and spectroscope, and of whose true nature we are nearly ignorant from lack of opportunity to study it." On page 40, the same author says—"The Sun went out as suddenly as a blow-out gas jet, and I became as suddenly aware that all around there had been growing into

vision a kind of ghostly radiance, composed of separate pearly beams, looking distinct each from each, as though the black circle where the Sun once was, bristled with pale streamers, stretching far away from it in a sort of crown. This was the mysterious corona, only seen during the brief moments while the shadow is flying overhead."

The French astronomer, Flammarion, says in his "Popular Astronomy," "What, then, is the corona? It is probably a region in which is found a variable quantity of detached particles, partially or wholly vaporized by the intense heat to which they are exposed. But how can these particles be supported in these burning heights? To this question we are already able to give three replies: (1), The matter of the corona may be in a state of permanent projection, being composed of substances incessantly darted out by the Sun and falling back on him. (2), The coronal substance may be more or less supported in the solar heights by the effect of a calorific or electrical repulsion. (3), Finally the corona may be due to clouds of meteors, aerolites circulating around the Sun in his immediate vicinity. All these explanations are perhaps in part true." In Proctor and Ranyard's "Old and New Astronomy" we read as follows: "But it is evident on the one hand that no simple theory can be advanced in explanation of the phenomena of solar appendages manifestly complex and varied, and on the other that the details of coronal structure and of coronal phenomena present problems far too difficult to be as yet solvable."

Miss Clerke in her "History of Astronomy during the Nineteenth Century," says—"The corona is properly described as a solar appendage, and may be conjecturally defined as matter in a perpetual state of efflux from and influx to our great luminary, under the stress of electrical repulsion in one direction and of gravity in the other. Its constitution is of a composite character. It is partly made up of self-luminous gases, chiefly hydrogen, and the unknown substance giving the green ray, "1474;" partly of white-hot solid or liquid particles, shining with continuous light, both reflected and original. The coronal materials must be of inconceivable tenuity, since comets cut their way through them without experiencing sensible retardation. Summing up what we have learned about the corona during some forty-five minutes of scrutiny in as many years, we may state, to begin with, that it is *not* a solar atmosphere. It does not gravitate upon the Sun's surface and share his rotation, as our air gravitates upon and shares the rotation of the earth; and this

for the simple reason that there is no visible growth of pressure downward in its gaseous constituents; whereas, under the sole influence of the Sun's attractive power, their density should be multiplied many million times in the descent through a mere fraction of their actual depth."

It is easily seen from the preceding extracts that the corona of the Sun has been visible only on those rare occasions when solar eclipses are total; and the very short period of time during which a total eclipse lasts at any given point upon the Earth's surface, renders any examination of the corona a very difficult operation. Since the introduction of the camera and the spectroscope, as adjuncts in all solar research, the amount of time and labor devoted to such work has been multiplied more than twofold. All the great observatories of the world are systematically engaged in trying to solve the mystery of the corona. Mountain peaks, clear skies, and rare atmospheres, have been sought for, and expensive trips to far away lands have been undertaken, in order to determine once for all what this wonderful thing may be which persists in withholding from the inquisitive eye its secrets and its nature. Men have gone half way round the globe to witness for one, two or six or seven minutes at most, the most beautiful object visible in the solar system. The question naturally arises—is it possible, or will it *ever* be possible, for the human eye, with or without any kind of instrument, and at *any* time to look upon and examine at leisure, such a glorious appendage as that of the Sun's corona? Will this nineteenth century, so full of splendid achievement in every field of scientific research, add to its other honors that of having made it possible, in the absence of a total eclipse, to see the corona? All efforts hitherto made have been without avail, have utterly failed.

In 1866, Mr. Lockyer, and in 1868, Janssen, made it possible for one to see at any time of the day when the Sun is above the horizon, and not obscured by clouds, the so-called "protuberances" or "prominences," that up to that time had been considered as mysterious as the corona is now. Miss Clerke says—"The eclipse of 1868 is chiefly memorable for having taught astronomers to do without eclipses, so far, at least, as one particular branch of solar inquiry is concerned. Inspired by the beauty and brilliancy of the variously tinted prominence-lines revealed to him by his spectroscope, Janssen exclaimed to those about him, "Je verrai ces lignes-là en dehors des eclipses!" On the following morning he carried into execution the plan which formed itself in his brain, at the time of the eclipse.

More than a year ago an idea took possession of my brain that there must be some method by which the corona of the Sun may be rendered visible at any time between sunrise and sunset, atmospheric conditions being favorable. In the latter part of April, 1899, I secured three strips of pine lumber, each about six or seven feet long, and of a uniform thickness of three-fourths of an inch. The strips were fastened to the outside of the tube of a Clark telescope of six inches object glass, separated from each other by a distance of 120°. Ordinary wrapping twine was used with which to make the strips secure and firm in their position. They were so placed that about three feet of each one was allowed to project beyond and in front of the object glass. This done, a card board, sufficiently heavy, was cut into the form of a circular disc of seven inches diameter. Upon the inside of the circumference of the disc, and as close to the limb as possible three small holes were pierced, through which pieces of fine, flexible wire were put, and these were tied around the pine strips. By this arrangement the card-board disc—an artificial moon—could be securely held in position, and by slipping the wires forward or backward, as might be necessary, the disc could be made to hide completely the entire face of the Sun. It was expected and hoped that the effect would be the same as in the case of a true solar eclipse, that is, that the solar appendages would be revealed. All things being ready, the telescope mounted firmly upon the tripod, the pine strips fastened, and the card-board moon put at a suitable distance from the object glass, on the afternoon of May 3d, 1899, the first trial was made, an observation was taken. The face of the Sun being completely obscured, bright radiations were seen to issue from the limb of the artificial moon in great numbers. These radiations were carefully scrutinized, but it was soon made apparent that they were nothing but streaks of light of a decidedly brassy appearance, reflected from the inside of the telescope, the barrel of which was made of brass. The card-board moon was now shifted to a point a little farther away from the object glass. The result was still the same, the brassy streaks, and all else. During all this time, and in spite of every effort to prevent it, the barrel of the telescope was flooded with light that poured into it from the surrounding atmosphere. Just here seemed to be the difficulty, the light came into the telescope apparently from everywhere past the limb of the false moon.

For over an hour, slight changes were made in the position of the false moon, at intervals of from five to six minutes each, at

one time to a place nearer the object glass, at another to a point further away, but all to no effect, the results were invariably the same, save that the brassy streamers were modified accordingly. Matters were becoming monotonous and rather disheartening, so much so that the question arose whether the observation should be prolonged, or given up as a flat failure. The determination to succeed, or know the reason why success should not be attained, prolonged the work for some time longer. The time passed in shifting the false moon, readjusting the pine strips, keeping the telescope in proper position, straining the eye in order to see the sight should a revelation be made, yet nothing was seen but the brassy reflections from the telescope itself, which seemed to be dancing and laughing as if in very mockery at every attempt to succeed. More than two hours had passed, and the goal to be reached was apparently as far off as ever. The observer was quite disheartened and discouraged, and about ready to give up in despair. In such a frame of mind, and quite willing to give it up as a bad job, suddenly and unexpectedly the false moon, for some reason or other, changed its position slightly, so that apparently its surface and the surface of the object glass were no longer parallel to each other. Whether the lack of parallelism was a fact or not, cannot now be determined. The effect produced was that the barrel of the telescope seemed to be completely filled with absolute darkness, the brassy streamers vanished, and along the upper right hand limb of the false moon appeared in all their beauty and soft light the coronal streamers. There was no mistaking the vision. It was the genuine corona itself, "a thing of beauty," and a glorious recompense for the time and labor that had been expended.

An attempt to change the position of the telescope so as to hold the Sun in the field, resulted in destroying the vision, and the coronal streamers disappeared from view. The following is a fac simile of a hand made drawing of the corona as seen on the afternoon of May 3d, 1899. It is not a complete coronal form, for the reason that the cardboard disc extended beyond the limb of the Sun, and prevented a view of the streamers other than as represented.

Several cardboard discs, one six inches in diameter, one seven, and another eight inches in diameter, were made and used at varying distances. A great many obstacles had to be met and surmounted in preparing for the work, and great care had to be exercised in handling the apparatus. The telescope used was mounted on a tripod, and was exposed to the action of the wind.

There was no driving clock attachment, so that every movement had to be made by the observer, thus rendering the labor so much the more difficult. Other observations were taken in May

Observation of Supposed Corona of the Sun Without an Eclipse.

and in June, but on account of ill health, the observations had to be suspended during the summer, and there has been no opportunity since to resume them.

But that the corona of the Sun was seen on the 3d of May, 1899, a day upon which there was no eclipse of the Sun, either partial or total, can scarcely admit of doubt. There is a possibility that it may have been a vision of something else, an optical illusion, an "ignis fatuus," or a dream.

At the moment when the picture was sketched, the "apparition" was situated in the vicinity of one of the poles of the Sun, and not in the plane of the Sun's equator, and so clear and well defined was the shape, and so different from all other appearances, that the conclusion reached by the observer was that it was the corona itself. To be sure, he may have been mistaken, but he thinks not, and it is unfortunate that the observation of

May 3d, has not as yet been corroborateq by other observations. The work will be resumed in the near future.

The difficulty in the case consists not in making an artificial Moon, attaching it to a telescope, and locating it at a proper distance from the object glass, but in flooding the barrel of the telescope with absolute darkness. When that is done, all other difficulties will seem but trifles and will vanish at once. The light of the Sun that fills the surrounding atmosphere is the great foe to anything like success and seems to bid defiance to every attempt. Shut out that light, exclude it entirely from the interior of the telescope by means of a conical hood that will extend some distance over the barrel of the telescope and forward as far perhaps as the false moon, or further, and with the conveniences and appliances of a modern Observatory, the result may be safefly predicted—the corona will be made visible.

In conclusion, if the corona was seen, upon the day mentioned, when there was no eclipse of the Sun, as described in the foregoing, I think I am justified in saying that the same thing can be done again and again, upon any clear day, during the hours of sunshine, no clouds interfering and other atmospheric conditions being suitable, and the question as to the possibility of astronomers seeing and studying the greatest mystery of the Sun at any time will be settled once for all.

UNIVERSITY OF KANSAS, Lawrence, Kansas.

THE TOTAL SOLAR ECLIPSE OF MAY 28, 1900.

Reprint from *Science*.

The committee on the total solar eclipse of May 28, 1900, appointed at the Second Conference of Astronomers and Astrophysicists, presents herewith a preliminary report.

The aim of the committee has been:

1. To asertain the opinion of astronomers regarding the best means of securing coöperation, the most important classes of observations and the best means of making them, and the plans of the various eclipse parties.

2. To collect other information likely to be useful to persons planning to observe the eclipse.

For the purpose of securing information on the various points referred to in paragraph (1) a circular letter was addressed to American astronomers. From an examination of these replies it appears:

1. That there is a general willingness to coöperate with the committee in securing thorough observations of the eclipse phenomena and effective distribution of stations along the line of totality.

2. That, in the opinion of those from whom the replies were received, the most important observations include studies of the minute structure of the corona, both visually and by means of large scale photographs; photography of the flash spectrum and determination of the wave-length of the green coronal line; measurement of the heat radiation of the corona; photographic search for an intra-mercurial planet.

3. That several institutions, including the Princeton, Lick, Naval, Goodsell, Chabot, Flower and Yerkes Observatories, will probably be represented by well-equipped parties, while a considerable number of astronomers with good instrumental equipment will take part as individuals.

4. That no general appeal to the public for funds is required, as each institution will endeavor to secure the amount necessary for its work.

5. That the work already planned includes observations of contacts, photography of the corona with large and small cameras; visual and photographic observations of the spectrum of the Sun's limb and of the corona; visual examination of the details of the coronal structure; measurement of the brightness of the sky at different distances from the Sun; search for an intra-mercurial planet; and observations of the shadow bands.

A preliminary report on the weather conditions along the line of totality has been prepared by the Weather Bureau, at the request of the committee. From this it appears that interior stations are probably to be preferred to those on the seacoast, in spite of the shorter duration of the total phase. The full report of the Weather Bureau, which will soon be published, will contain much valuable matter, including maps of the eclipse track, showing location of towns and railways; information regarding hotel accommodations, desirable sites, etc.

It is understood that the Naval Observatory will issue instructions to observers, and that a map of the eclipse track will be published by the Nautical Almanac Office. The Treasury Department has made arrangements by which the instruments of foreign parties will be admitted free of duty.

The committee, if authorized by the conference to continue its work, will be glad to receive and publish further information from eclipse parties regarding their plan of observations and location of stations.

Extracts from the replies of various astronomers were appended to the report, but need not be reproduced here, as they have been published in the *Astrophysical Journal.* The committee was continued in office.

The committee appointed at the Second Conference to act in reference to the questions at issue regarding the United States Naval Observatory also reported that the opinions of astronomers regarding that institution, which had been obtained in response to a circular letter, had been communicated to the Secretary of the Navy. This report is not reproduced here, as it is practically superseded by the official report of a Board of Visitors appointed by the Secretary of the Navy to visit, examine and report upon the Naval Observatory. The recommendations of this official report have been given in full in *Science.*

The first meeting of the Astronomical and Astrophysical Society of America adjourned at noon, September 8th.

EDWIN B. FROST, Acting Secretary.

YERKES OBSERVATORY, Williams Bay, Wis.

PACKING INSTRUMENTS FOR TRANSPORTATION.

SABRA C. SNELL.

FOR POPULAR ASTRONOMY.

The repeated experiments of Professor Todd, of Amherst College, in transporting delicate apparatus over great distances make valuable the method of packing he has been led to adopt. His experience is that the safest packing material is cork saw dust closely confined in cloth bags of various shapes and sizes.

This cork may be obtained from any dealer in Malaga grapes. It should be looked over to remove all foreign substances, then washed and thoroughly dried. That as little water as possible be absorbed; put not more than two or three quarts at a time into three or four times as much lukewarm water; press it under and rub between the hands till the whole has been treated; the dirt thus loosened will mostly sink, while the cleased cork floats. Skim off carefully and squeeze or drain, till dry enough to spread in the Sun. If one is possessor of old fashioned quilting frames, nothing is better; set up in a sunny room, with a large square of cotton cloth stretched over them, they furnish space for spreading a bushel at once under most favorable circumstances. The drying process should be very thorough, and

to insure this, it is safe to heat the cork in large flat pans in an oven after it feels perfectly dry to the touch. Any moisture remaining in the pores is thus drawn out.

The bags are made of firm cotton, closely stitched and filled nearly as hard as a pincushion. Mostly small sizes are serviceable, but for packing a large lens, two squares, each divided into several compartments, furnish good protection. Also, if it is desired to put tubes within others, long bags, a few inches only in width, filled and bent into rings, serve to separate them.

The elasticity of the cork, together with the possibility of almost perfect freedom from dust, make it for this use superior to any other substance yet tested.

GROWTH OF A GREAT AMERICAN OBSERVATORY IN TWENTY YEARS.*

The financial condition of the Harvard College Observatory has undergone a great change during the last twenty years. The invested capital on August 31, 1877, was $173,908.67, and for the preceding year yielded an income at the rate of 6.36 per cent. The total receipts of the Observatory were $14,359.55. On July 31, 1898, the invested capital was $825,699.30, and for the preceding year yielded an income at the rate of 4.37 per cent. The total receipts were $46,175.46. Accordingly, during this time the principal has increased about four and a half times, while the income has increased three times, although the rate of interest has diminished by nearly one-third. This remarkable growth in our resources has been attained in a great measure through the Visiting Committee of the Observatory. When appointed Director in 1877, I showed that a small addition to the income would greatly increase the efficiency of the work. The Committee accordingly secured by subscription the sum of $5,000 a year, for five years, from seventy-two persons. While nearly all the members of the Committee took part in this work, its success was due to the unremitting efforts of three persons, Mr. Alexander Agassiz, Chairman, Mr. J. Ingersoll Bowditch, and Mr. William Amory. At the end of the five years the Observatory seemed to be poorer than before, since we had learned how much could be accomplished by a moderate increase in its

* Report of Professor E. C. Pickering Director of Harvard College Observatory to the Board of Overseers of Harvard College May 1899. The article is his, the title ours.—[EDITOR.

means. Accordingly, a second subscription of $50,000 was undertaken by the Committee, the Rev. James Freeman Clarke, Chairman, also taking an active part. Not only was this sum obtained but the indirect results were even greater. Two gentlemen were asked to subscribe and both declined. It afterwards appeared that each made his will at about that time, and within a fortnight of each other, each leaving his entire fortune for astronomical purposes. Both of these sums, forming two of the largest bequests that have ever been made to astronomy, have now come into the possession of the Observatory. Mr. Robert Treat Paine, for forty-one years a member of this Committee, bequeathed his entire fortune, amounting to $323,557.86, to this Observatory. Mr. Uriah A. Boyden left his property to Trustees, to coöperate with some institution, for the purpose of establishing an astronomical station at a high altitude and under the most favorable atmospheric conditions. One of the Trustees, Mr. James B. Francis, visited the observatories all over the United States, and was strongly advised to coöperate with the Lick Observatory, or with the Smithsonian Institution, but after a long correspondence and numerous interviews I was able to satisfy him that the means we had already secured would enable us to carry out Mr. Boyden's wishes better here than could be done elsewhere. Accordingly, this bequest, exceeding two hundred thousand dollars, also came to the Observatory. The next addition to our resources is one of the most important that we have received, in its objects, its results, and its amount. A member of this Committee, Mrs. Henry Draper, desiring to develop and extend the work so skillfully begun by her husband, established here the Henry Draper Memorial. Her gift of $10,000 a year has enabled the spectra of the stars to be studied photographically, as was first done successfully by Dr. Draper, on a scale which has not been attempted elsewhere, and with results which in number and importance render it perhaps the most widely useful department of the Observatory. A Memorial has thus been established, in the most appropriate manner, which perpetuates the memory of the founder of this department of science. Without the Paine and Boyden Funds it is doubtful if the work of the Henry Draper Memorial could have been conducted more advantageously at Harvard than elsewhere. Each of these funds aids the other, and greatly assists in securing new donations. Thus, when Miss Bruce of New York was asked to give us a photographic telescope of the largest size, it was easy to show that we had

here appliances to attain with it the best possible results. Her gift of $50,000 has furnished us an instrument for photographic research, far more powerful than any now existing elsewhere. Several other bequests have been received, the largest and latest of them, the Haven Fund, amounting to $45,000. With the Boyden, Draper, and Bruce photographic telescopes many thousand photographs were obtained, which are of the greatest value, but if destroyed could never be replaced. Yet for several years we were obliged to store them in the wooden buildings of the Observatory, where they were liable to destruction in a few hours at any time, by fire. Again the Visiting Committee came to our assistance, and largely through the efforts of the Chairman, Mr. George O. Shattuck, $15,000 was raised by subscription, and a fire-proof building was erected in which the photographic plates are safely stored, examined, and measured.

The Observatory has thus grown by successive steps until it now has organized departments for research, some of which are at least equal to those of any other Observatory, either public or private, even including those maintained by the governments of England, France, Germany, and Russia. The work of the Observatory has increased more rapidly than its means. The number of assistants has increased from six to forty. During the first thirty years of its existence four volumes of its Annals were published and distributed, and three or four more were partially completed or ready for distribution. The total number of volumes is now forty. Besides the Station at Cambridge, the Observatory maintains a permanent Astronomical Station at Arequipa, Peru, where the atmospheric conditions are much better than at other observatories, with perhaps two or three exceptions. It also maintains seven meteorological stations in Peru, including the highest in the world, that on El Misti, elevation 19,200 feet. By coöperation with the Blue Hill Meteorological Observatory, the excellent results obtained at the three stations of that Observatory are published in our Annals.

The scientific work of the Observatory since its establishment has been in the direction of the physical properties of the stars rather than in merely measuring their positions. This line has been especially pursued for the last twenty years, and has developed fields of work that have not been taken up elsewhere. The station in the southern hemisphere enables researches on the northern stars to be extended to the south pole, permitting all stars in the sky to be studied according to a uniform system. Thus, after measuring with the meridian photometer all the

northern stars visible to the naked eye, the instrument was sent to Peru and similar measures were made of the southern stars. All stars north of $-40°$, of the magnitude 7.5 and brighter, have since been measured, besides several thousand stars of the eighth and ninth magnitude. About nine hundred and thirty thousand settings of about forty-five thousand stars have been made with the meridian photometer since 1879, and a more powerful instrument now enables stars of the thirteenth magnitude to be measured. Measures are also made of the light of faint stars every clear evening with the 15-inch Equatorial telescope.

Measures of position have not been neglected. The observations of a zone of 8,627 northern stars with the Meridian Circle, in connection with twelve other observatories, have been completed, and the results published occupy seven volumes of the Annals. The observations of a similar zone of southern stars are completed and good progress has been made in their reduction. Several photographic telescopes are kept in constant use, both in Cambridge and Arequipa, throughout the whole of every clear night. As a result about eight thousand photographs are taken every year, and the entire collection of nearly a hundred thousand plates are carefully studied by about a dozen assistants. These plates show the spectra of all the stars in the sky brighter than the tenth magnitude. They also furnish charts showing the condition of the entire sky several times every year, and contain a history of the visible universe during the last ten years. A striking illustration of the value of this collection is shown in the recently discovered planet Eros, which comes nearer to the Earth than any other known celestial body except the Moon. Its nearest approach occurs every thirty-seven years, the last time being in 1894, when no visual observations were obtained, since it was not discovered until five years later. Its path from October 1893 to May 1894 is shown by fifteen of our photographs, each of which also gives its position with an accuracy equal to that of a meridian circle. The laborious computation required in this search for Eros has been made for this purpose by Mr. S. C. Chandler. No photograph of Eros was obtained in 1893, at any other observatory. Other even more interesting objects may yet be discovered, and are doubtless contained on our photographs, since the latter cover the entire sky for the last ten years.

The results here described have been attained by rigorous economy, in spending money only to obtain results, and in no case for

display. No money is expended on architectural effect, and in the buildings and instruments appearances are always sacrificed to efficiency. The salaries, especially those of the younger assistants, are much lower than their services deserve.

A serious question now arises regarding the future of the Observatory. It has attained a position among the great Observatories of the world. This position, I believe, it should maintain, and I believe that Harvard University, and the people of the United States, desire that it should do so. If the Observatory is to do the work it did twenty years ago, its means are more than ample. If it is to do its present work, and maintain its present position, there must be no diminution in its income, but rather a steady, if gradual, increase. Unfortunately, the gradual falling off in the rate of interest affects a large portion of the resources of the Observatory. For this reason the income has been diminishing at the rate of a thousand dollars a year, for the last six years, and we are far from reaching the lowest point. One per cent. in the rate of interest means a loss to the Observatory of about ten thousand dollars a year. A diminution in income means abandoning work already undertaken, losing assistants at the very time when they have attained their greatest usefulness since their salaries cannot be gradually increased, and postponing the reduction and publication of observations already made. Such a course is the worst possible economy. Delay in publication often means a great increase in expense if material accumulated by one person must later be put into the hands of another, and often, as has frequently happened at other Observatories, a loss of the entire work.

In view of the wide interest in astronomy, and its numerous and generous patrons in this country, there are doubtless many persons who would gladly meet this need if it were properly brought before them. Unfortunately, the legacy tax of the United States, amounting in some cases to fifteen per cent. of an entire bequest, is likely to discourage gifts to science, instead of inducing donors to give during their lives.

As a remedy for these difficulties, it is suggested that the attention of the public be called to these facts by publication, and that the statement be made that it is desired to increase the capital of the Observatory by $200,000, to compensate for the loss of income due to falling off in the rate of interest. If this amount cannot be obtained the sum of $50,000, if expended during the next ten years, would provide for the reduction and publication of a large part of the material now on hand.

A PHOTOGRAPH OF THE SUN.

H. C. WILSON.

The photograph of the Sun shown in Plate III was taken May 18, 1894, at $4^h\ 41^m$ Central Standard Time with the 8-inch Clark refractor. This telescope is provided with a third lens placed in front of the visual objective to correct it for the photographic rays. It is also provided with two amplifiers by Brashear and Hastings, one throwing up the solar image to approximately $3\frac{1}{2}$ inches, the other to 7 inches diameter. The greater amplifier was used for this picture, which has been reduced in the process of engraving.

The photograph was taken at a time not far from the maximum of the Sunspot period, and a large number of spots are shown upon the plate. Seven groups lie in the zone south of the solar equator and two very small groups in the zone north of the equator. The solar equator is inclined about 20° to the horizontal in this picture, being tilted down on the right and up on the left hand, and passes a little above the center of the disc, the solar latitude of the center of the disc being approximately $-2°$. The row of five prominent groups of spots thus lie on a line nearly parallel to the solar equator.

The most prominent of the groups, in the lower right portion of the disc is about 60,000 miles long and of half that width. It has three marked centers of disturbance, or umbræ, and a comparison of this photograph with one taken on the next day, shows that the whole group was in a state of violent change. Surrounding the group of dark spots on all sides are irregular areas of white faculæ. Scattered patches of like character are to be seen at several points near the east and west edges of the disc, generally in connection with the dark spots but sometimes entirely separated from them. The area covered by the white faculæ is as a rule much greater than that covered by the dark spots.

The group just below the center is remarkable for the number of small separate dark spots which it contains. The photograph taken on the next day shows many of these run together, while the larger spots are more intense and changed in form, so that the change in one day is quite noticeable.

To the left and a little below the center of the disc is a group of less prominent spots, the leader of which is rather large and has four u nbræ forming a parallelogram. On the next day these four umbræ had united into one very black pear-shaped umbra, with

the large end toward the right, making this group almost as remarkable as those which precede it.

Nearer the left edge of the picture is a single almost round spot, in the upper part of a large group of faculæ. Higher on the left, quite near the edge of the disc, a conspicuous dark spot may be seen, having a white cloud or facula on its left and apparently over it. Another umbra lies to the left of this, almost lost in the dark shading due to absorption of light by the solar atmosphere, which produces its greatest effect at the edge of the disc. Almost exactly at the left edge of the disc, wholly lost in the print but plainly seen in the negative, two large spots are just coming into view. The rotation of the Sun once in 26 days carries the spots across the disc approximately from east to west, so that these spots on the next day are well in view.

Many finer details which cannot be brought out in the engraving, such as the fine mottling or grain of the solar surface, are to be seen in the photographic print and still better in the negative.

SPECTROSCOPIC NOTES.

The important Potsdam investigation of the spectra of 528 stars (*Untersuchungen uber die Spectra von 528 Sternen.* H. C. Vogel und J. Wilsing. *Potsdam Publicationen No. 39*) is the subject of an appreciative review in the *Astrophysical Journal* for December, where the chief results are more accessible than in the original memoir. The stars under investigation are mostly of Class I, to which the photographic method with the ordinary plates is well adapted, and the list includes all the brighter stars of that class. The instrument employed was one of moderate power only, sufficient to give photographs suitable for comparison and classification. Class I is thus subdivided:—

Ia1. Spectra containing only strong hydrogen lines.

Ia2. Spectra containing strong hydrogen lines, and faint metallic lines, with *K* a sharply defined line.

Ia3. Spectra containing strong hydrogen lines, numerous metaliic lines, with *K* strong and usually a diffuse band.

Ib. Spectra containing strong hydrogen lines, helium lines, and some metallic lines.

Ic1. Spectra containg bright hydrogen lines.

Ic2. Spectra containing bright hydrogen lines, and bright helium lines, and perhaps other bright lines.

The distribution by number is, Ia1, 44; Ia2, 168; Ia3, 68; Ib 100; Ic1, 3; Ic2, 2; together with a few given as intermediate between various classes. The spectra of the two stars of Ic2 belong also to Ia2 by reason of the presence of helium lines. The review summarizes the section of the work devoted to a discussion of stars with remarkable spectra,—such as φ Persei, γ Cassiopeiæ, β Lyræ, P Cygni,—and closes with an account of the companion of the Potsdam with the Harvard results and classification.

Herr Belopolsky contributes to the *Astrophysical Journal* for December the results of his investigation at Pulkova of the spectrum of P Cygni. In this star, which shows the hydrogen and other lines both bright (Ic2 in the Potsdam classification) and dark, the bright lines are seen to be about in coincidence with the comparison lines, while the dark lines are strongly displaced toward the violet. Herr Belopolsky finds a bright and dark line in the star's spectrum corresponding to each of the several comparison air lines due to nitrogen.

In the *Observatory* for December, Mr. Newall announces his confirmation of Professor Campbell's discovery that Capella is a spectroscopic binary; and states that before Professor Campbell's note on the subject had been received in England he had presented a short preliminary note to the Royal Astronomical Society to announce the binary nature of the star.

Dr. Wilsing describes in the *Astrophysical Journal* for December the Potsdam photographic photometer, with which his measures of the relative albedo of Mars and Jupiter were made.

In the conferring of the British new year's honors, Captain William deW. Abney, whose researches in photography are well known to students of the science, and who was the first to photograph the infra-red of the solar spectrum, was designated a Knight Commander of the Bath (K. C. B.).

In his letter to the Board of Visitors to the Naval Observatory at Washington Professor Brown, writing in anticipation of his recent appointment to the position of Astronomical Director of the Observatory, states that the necessary accessories have been provided to enable the Naval Observatory to join in the work of determining motions of stars in line of sight, and that such observations are now a part of the routine work of the Observatory. He expresses his opinion that the time of the 26-inch telescope should be divided equally between this work and micrometric measures.

The *Astrophysical Journal* for December contains a short note by Professor Young on his original mistaken identification of the corona line with the 1474 chromosphere line. He states that his plan of placing the micrometer wire on the corona line, at the last moment, to fix its position was frustrated both in 1870 and in 1878 by the premature ending of totality.

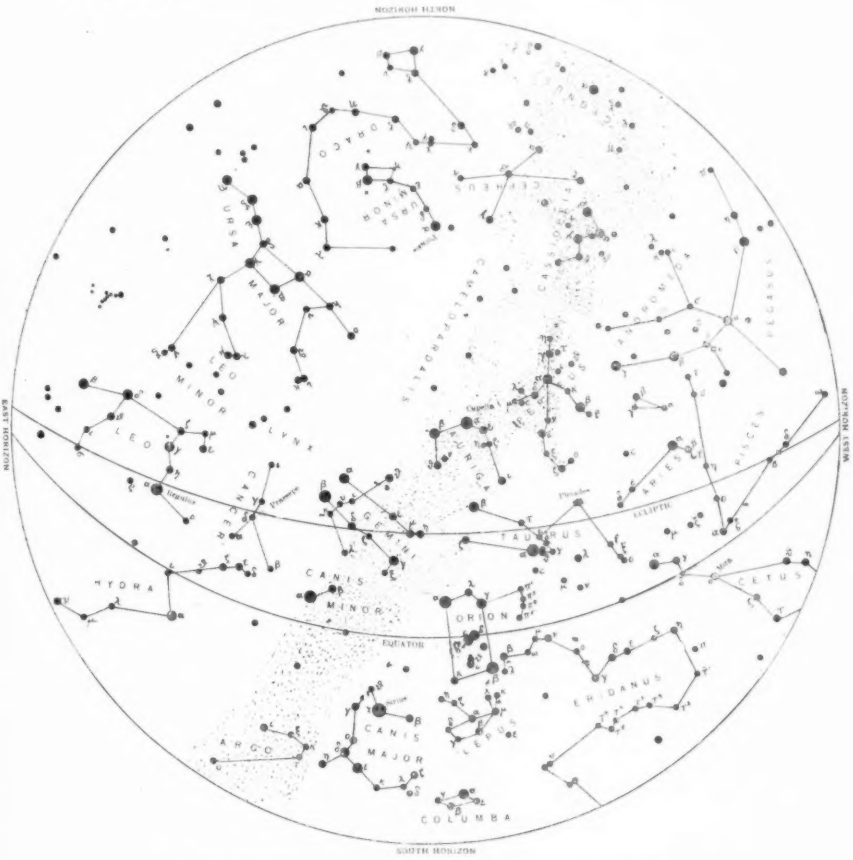
PLANET NOTES FOR FEBRUARY.

H. C. WILSON.

Mercury will be behind the Sun during this month, passing superior conjunction Feb. 9, and coming out so as to be visible as evening star in the last days of the month. Mercury passes Mars on the morning of Feb. 3, when both planets will be invisible.

Venus is exceedingly brilliant now in the early evening, and may be seen with the naked eye at any time in the afternoon if one knows just where to

direct the eye. Her position is becoming more favorable all the time and her brightness steadily increasing, while she now outshines many fold any of the stars. Observations, however, must be made early in the evening, preferably before sunset, for Venus sets at about 8 o'clock on Feb. 1 and at about 9 o'clock at the end of the month.



THE CONSTELLATIONS AT 9 P. M., FEBRUARY 1, 1900.

Mars was at conjunction with the Sun Jan. 15 and moves so slowly, relative to the Sun, that he will not be observable for several months.

Jupiter will be at quadrature, 90° west from the Sun, Feb. 28, and so may be observed in the morning an hour or two before sunrise. The altitude of Jupiter will, however, be too low for favorable observations.

Saturn may also be seen in the morning toward the southeast but in less favorable position than that of Jupiter, so that most of us will wait until the spring and summer months for our study of this wonderful planet.

Uranus is in Scorpio between Jupiter and Saturn (see chart in Jan. 1900 No. of POPULAR ASTRONOMY, p. 39), and so to be seen under the same unfavorable conditions.

Neptune is the only planet which can be seen in the evening at a high altitude. This planet requires a powerful telescope to show its disc, but it may be seen and its movement noted with a telescope of three or four inches aperture. It is to be found in the region northeast of the star ζ Tauri, R. A. Feb. 1, $5^h\ 36^m\ 12^s$, Decl. + 22° 3′; Feb. 28, R. A. $5^h\ 35^m\ 2^s$, Decl. + 22° 4′.

The Moon.

		Phases.	Rises. (Central Standard Time at Northfield; Local Time 13m less.) h m	Sets. h m
Feb.	6	First Quarter..... 10	42 A. M.	2 09 A. M.
	14	Full Moon..... 6	11 P. M.	7 17 "
	22	Last Quarter..... 1	23 A. M.	10 33 "
Mar.	1	New Moon..... 6	32 "	6 47 P. M.

Occultations Visible at Washington.

Date. 1900.		Star's Name.	Magnitude.	IMMERSION. Washington M. T. h m	IMMERSION. Angle f'm N pt. °	EMERSION. Washington M. T. h m	EMERSION. Angle f'm N pt. °	Duration. h m
Feb.	2	19 Piscium	4.9	10 34	105	11 12	218	0 38
	4	104 Piscium	7.5	12 10	47	12 52	288	0 42
	5	27 Arietis	6.3	10 35	118	11 21	223	0 46
	6	τ^1 Arietis	5.3	8 16	52	9 24	291	1 08
	6	65 Arietis	6.0	9 16	50	10 16	298	1 00
	7	χ^1 Tauri	4.7	11 32	94	12 36	272	1 04
	7	χ^2 Tauri	6.3	11 36	115	12 35	251	0 59
	11	5 Cancri	6.3	13 50	169	14 33	241	0 43
	13	*h* Leonis	5.7	9 51	85	11 05	334	1 14
	15	p^2 Leonis	5.4	12 13	139	13 40	291	1 27
	16	B.A.C. 4006	6.1	15 31	162	16 37	262	1 06
	17	*q* Virginis	5.7	13 34	152	14 51	275	1 17
	21	δ Scorpii	2.6	18 49	37	19 35	335	0 46
	22	15 Ophiuchi	7.3	12 12	65	12 59	317	0 47
	22	22 Ophiuchi	6.7	17 17	44	18 11	327	0 54
	24	31 Sagittarii	7.0	16 39	142	17 18	209	0 39

VARIABLE STARS.

J. A. PARKHURST.

Maxima and Minima of Long Period Variables.

MAXIMA. 1900 Feb.	Mag.	Day.	MINIMA. 1900 Feb.	Mag.	Day.
845 R Ceti	8.2	1	466 U Piscium	14.7	15
1635 R Reticuli	7	16	782 R Arietis	12	16
2445 W Monocerotis	8.8	28	893 U Ceti	12	8
2776 W Puppis	9.5	2	980 V Persei	10	8
2857 U Puppis	8.8	27	2528 R Geminorum	13.5	9
3495 / Carinæ	3.7	27	2625 V Geminorum	13	23
(3879 RR) Hydræ	8.5	6	2676 U Monocerotis	7.1	25

MAXIMA.

1900 Feb.

	Mag.	Day.
3890 W Leonis	9	17
5037 RR Virginis	11	27
5174 RS Virginis	8.2	6
5504 S Coronæ	7.0	28
5644 Z Libræ	11	23
5758 X Herculis	6.1	17
5795 W Scorpii	10.6	20
5830 R Scorpii	10	9
5955 R Draconis	7.6	15
6794 R Lyræ	4.0	9
6892 RX Sagittarii	9.9	7
6900 W Aquilæ	7.5	26
7106 S Vulpeculæ	8.7	13
7260 Z Aquilæ	8.9	16
7456 RR Cygni	8.4	5
March.		
103 T Andromedæ	8.0	16
114 S Ceti	7.5	12
494 R Sculptoris	6.6	20
715 S Arietis	9 5	15
1222 R Persei	8.5	22
1383 T Eradini	7 2	26
1582 S Tauri	9.7	21
1717 V Tauri	8.9	7
2583 L Puppis	3.5	14
2676 U Monocerotis	8.6	15
2780 T Geminorum	8.4	17
3567 V Leonis	8.6	28
4471 T Canum Venaticor.	8.7	31
4511 T Ursæ Majoris	7.3	14
4521 R Virginis	7 3	3
4896 T Centauri	5.9	8
5438 Y Libræ	8.5	14
5566 RU Libræ	8.5	26
5617 U Libræ	9	11
5752 RZ Scorpii	7.8	18
5950 W Herculis	8.2	30
6225 RS Herculis	8.0	25
6512 T Herculis	7.7	24
6682 X Ophiuchi	7.9	7
6794 R Lyræ	4.0	27
6921 S Sagittarii	9.8	13
7085 RT Cygni	7 3	5
7257 R Sagittæ	8.6	18
7431 S Delphini	9.1	29
8324 V Cassiopeæ	7.5	7

MINIMA.

1900 Feb.

	Mag.	Day.
2742 S Geminorum	< 13.5	8
2976 V Cancri	12	19
3495 / Carinæ	5.2	13
3825 R Ursæ Majoris	12.9	23
4557 S Ursæ Majoris	10.9	8
6100 RV Herculis	< 15	12
7252 W Capricorni	< 14.7	24
7571 V Capricorni	14 ?	6
7999 X Aquarii	13	25
8068 S Lacertæ	< 12	28
March.		
146 T Sculptoris	10.0	14
1577 R Tauri	13.0	18
2690 X Puppis	9.6	7
3477 R Leonis minoris	13	8
3495 / Carinæ	5.2	21
3637 S Carinæ	9.1	17
3994 S Leonis	< 13	7
4425 X Centauri	12.4	13
4596 U Virginis	12.5	31
4826 R Hydræ	9.7	25
4940 W Hydræ	8.0	14
5095 R Centauri	9.3	27
5249 V Libræ	12.2	20
5430 T Libræ	< 14.7	13
5758 X Herculis	7.0	21
6132 R Ophiuchi	< 12	27
6549 W Lyræ	12	18
6794 R Lyræ	4.7	5
6899 U Draconis	< 13	15
7106 S Vulpeculæ	9.5	26
7242 S Aquilæ	11.3	18
7257 R Sagittæ	10.1	2
7754 W Cygni	6.4	11
8373 S Pegasi	13	6

AUTHORITIES FOR THE ABOVE EPHEMERIS. The dates for the ephemeris of long-period variables are taken from M. Loewy's ephemeris as published in the *Companion to the Observatory* for 1900. The magnitudes are taken from Chandler's Third Catalogue for the stars contained in it, for the remainder they are taken from later announcements in the *Astronomical Journal*, or from personal observations. For the Algol-stars, the ephemeris for S Velorum and RS Sagittarii was computed from the elements in Chandler's Third Catalogue; for W Delphini from the same source; for + 12° 3557 from Luizet's elements in No. 3596 of the *Nachrichten*; for + 45° 3062 from Professor Pickering's elements in No. 3581 of the *Nachrichten*. The data for the rest of the Algol-stars were taken from M. Loewey's ephemeris in the *Companion to the Observatory*, but the times there

given are not the ordinary Astronomical Time, reckoning from noon to noon, but reckoned from the previous midnight, as for civil time, so that 12^h must be subtracted from the times as above given, to reduce to Greenwich Time. This matter was evidently overlooked by the editors of the *Companion*, for the statement is made in the introduction, "Greenwich Mean Time is used in all cases, and the astronomical day is reckoned from noon to noon as in previous years."

Minima of the Variable Stars of the Algol Type.

(Given to the nearest hour in Greenwich Time.)

1900 March.

U CEPHEI.

	d	h
Mar.	3	17
	8	17
	13	16
	18	16
	23	16
	28	15

ALGOL.

	d	h
Mar.	11	18
	14	15
	17	12

λ TAURI.

	d	h
Mar.	8	17
	12	16
	16	15
	20	13
	24	12

S. CANCRI.

d	h
6	18
16	5
25	17

R CANIS MAJ.

Every 3d min.
$P = 1^d\ 3^h.3$

	d	h
Mar.	3	13
	6	23
	10	9
	13	19
	17	4
	20	14
	23	24
	27	10
	30	20

S VELORUM.

	d	h
Mar.	1	12
	7	10
	13	9
	19	7

δ LIBRAE.

	d	h
Mar.	2	20
	7	12
	16	19
	21	11
	30	18

U CORONAE.

	d	h
Mar.	5	9
	8	20
	12	7
	15	18
	19	5
	22	16
	26	2
	29	13

U OPHIUCHI.

Every 4th min.
$P = 20.1^h$

	d	h
Mar.	2	0
	5	8
	8	17
	12	1
	15	10
	18	18
	22	3
	25	11
	28	20

W. DELPHINI.

	d	h
Mar.	18	19
	23	15

RS SAGITTARII.

	d	h
Mar.	1	16
	6	11
	8	21
	13	17
	18	13
	25	19
	30	15

+ 12°3557

	d	h
Mar.	6	21
	7	19
	8	16
	14	21
	15	19
	16	16

+ 45°3062.

	d	h
Mar.	5	6
	9	20
	14	10
	19	0
	23	13
	28	3

SS CYGNI. The abnormal maximum which was described in the January number of this magazine, has evidently made no interruption in the regular order of procedure with this remarkable star, for it rose suddenly to a maximum of the usual type some time between 1899, Dec. 30, and 1900, Jan. 1. Mr. Sperra fixed the above limits. I found it normal Dec. 29 and bright, about 8.6 magnitude Jan. 1.5. Mr. Flanery found it bright Jan. 2. This rise is about a week earlier than the ephemeris time given in Vol. VII, page 149, a correction quite comparable with those deduced from late maxima. In the table at the top of page 47 in the January number there should be 14 observations by J. A. Parkhurst, instead of 41.

DENSITIES OF ALGOL-TYPE VARIABLES. In the *Astrophysical Journal* for December, 1899, there are two interesting articles on the above subject, by Alexander Roberts and Henry Norris Russell. Mr. Russell says in introduction: "It is possible in the case of an Algol-star, assuming the eclipse theory of its variation, and a circular orbit, to deduce a limiting value for its mean density

from its period and the duration of its light-variation, any uncertainty as to the result being due to the uncertainty in the ratio between these two quantities, which is, as a rule, not yet very accurately determined." His results for "the seventeen known Algol-variables" are as follows—

Star.	Maximum Density.
320 U Cephei	0.098
1090 β Persei (Algol)	0.139
1411 λ Tauri	0.142
2610 R Canis Maj.	0.366
3055 X Carinae	0 261
3109 S Caneri	0 035
3416 S Velorum	0.061
5374 δ Librae	0.058
5484 U Coronae	0.137
5949 R Arae	0.145
6189 U Ophiuchi	0.298
6442 Z Herculis	0.728
6546 RS Sagitarii	0.086
7399 W Delphini	0.170
7488 Y Cygni	0.212
+12°3557	0.320
+45°5062	0.076

Mr. Roberts confines his attention to four stars whose elements are found from his own numerous observations at Lovedale, South Africa.

His results are in part—

3416 S Velorum, Bright star 0.61, Faint star, 0.03.
3055 X Carinae, Assuming equal masses, 0.125.
—— Lac 5861, Assuming equal densities, 0.14.
6546 RS Sagittarii, Bright star, 0.16, Faint star 0.21.

COMET AND ASTEROID NOTES.

Holmes' Comet.—In *Astronomische Nachrichten* No. 3610, Mr. H. J. Zwiers gives an extension of his ephemeris of Holmes' comet from Jan. 1 to Feb. 12, 1900. He says that he does not think that the comet can be observed in the second half of February. It is very doubtful whether the comet can be seen in the first half of the month. It has been exceedingly faint at best during this apparition, and its theoretical brightness is waning rapidly. No observations have been reported except with the most powerful telescopes.

Ephemeris of Holmes' Comet, *d* 1899.

1900	R. A.			Dec.			r (Aber.)	log Δ
	h	m	s	°	′	″	d	
Feb. 1	2	35	52.32	+39	27	36.6	0.01500	0.414920
2		37	02.99	39	24	12.0	.01510	.417635
3		38	14.56	39	20	54.0	.01519	.420339
4		39	27.01	39	17	42.5	.01529	.423033
5		40	40.32	39	14	37.4	.01538	.425716
6		41	54.46	39	11	38.5	.01548	.428387
7		43	09.43	39	08	45.8	.01557	.431047
8		44	25.10	39	05	59.1	.01567	.433696
9		45	41.75	39	03	18.3	.01576	.436332
10		46	59.06	39	00	43.2	.01586	.438956
11		48	17.11	38	58	13.8	.01595	.441568
12	2	49	35.88	+38	55	49.8	0.01605	0.444167

Tempel's Second Comet *c* 1899 (1873 II.)—This comet was observed at Lick Observatory by Professor Aitken on 10 nights, from Aug. 11 to Sept. 26. "In August and early in September the comet nucleus was very sharp, and the comet bright—easily visible in a 3½-inch telescope. On Sept. 26 it was faint enough to be difficult with the 12-inch refractor."

The same comet was also observed on twenty nights from July 11 to Sept. 9 with the transit circle of the Royal Observatory, Cape of Good Hope.

New Elements of Eros (433).—In *Astronomische Nachrichten* No. 3609 E. Millosevich gives elements of Eros based upon all available observations from Nov. 1898 to April 1899, combined into seventeen normal places.

Epoch and Osculation. Oct. 31.5, 1900, Berlin mean time.

$$
\left.\begin{aligned}
M &= 304^\circ\ 23'\ 59''.7 \\
\pi_1 &= 121\ \ 09\ \ 22.0 \\
\omega &= 177\ \ 38\ \ 41.6 \\
\Omega &= 303\ \ 30\ \ 40.4 \\
i &= \ 10\ \ 49\ \ 38.9
\end{aligned}\right\} 1900.0
$$

$$\varphi = 12\ \ 52\ \ 48.2$$

$$\mu = 2015''.12740 \text{ (Period 643.14 days).}$$

$$\log a = 0.1638027$$

An epemeris for the next opposition is given, extending from Sept. 1, 1900, to Jan. 31, 1901. The brightness of the planet will increase from 11.0 mag. Sept. 1 to 8.4^m Dec. 30 and after that diminish slowly.

Elements of Asteroid 1899 EY.—A supplement to *Astronomishe Nachrichten*, No. 3612, gives elements by Otto Knopf of the asteroid discovered by Charlois on Dec. 4, 1899, which was noted as being exceptionally bright for a newly discovered asteroid.

Epoch Jan. 0.0, 1900, Berlin mean time.

$$
\left.\begin{aligned}
M &= 345^\circ\ 32'\ 15''.3 \\
\omega &= \ \ 3\ \ 32\ \ 19\ .9 \\
\Omega &= \ 89\ \ 46\ \ 43\ .3 \\
i &= \ 15\ \ 22\ \ 20\ .0
\end{aligned}\right\} 1900.0
$$

$$\varphi = \ \ 5\ \ 13\ \ 16.4$$

$$\mu = 651''.293$$

$$\log a = 0.490821$$

The orbit is not very eccentric ($e = 0.09$) and the distance from the Sun is greater than the average for the asteroids, so that the brightness of this planet is not due to a near approach to the Earth but to relatively great size or albedo.

An ephemeris for the first few days of February follows. The brightness on Feb. 9 is calculated to be 10.2 magnitude.

	R. A.	Dec.	log r	log Δ
	h m s	° ′		
Feb. 1	4 10 44	+ 18 50.4	0.4500	0.3623
3	11 19	+ 19 01.9		
5	11 59	+ 19 13.5	0.4499	0.3719
7	12 46	+ 19 25.0		
9	4 13 39	+ 19 36.6	0.4498	0.3814

GENERAL NOTES.

Western Australia.—Meteorological report is received from Perth Observatory, for year 1898, W. E. Cooke, Gov. Astronomer. It is a very full report with 24 full page colored maps.

The Solar Parallax.—In *Comptes rendus* (Vol. 129, pp. 986-993) M. Bouquet de la Grye gives the results of a discussion, of the observations by the various French expeditions which observed the Transit of Venus in 1882. In this discussion an important fact is brought out which may not have come to the attention of observers very generally. It is the fact that the time of external contacts is influenced by the size of the telescope. In the case of internal contact the author does not find any difference due to size of instrument.

With large telescopes, observations show $p = 8''.7996$
" small " " " $p = 8$ .8068

From these results the mean parallax comes out 8″.80 from the visual observations of the French parties. The photographic results are not yet known.

In 1888, Professor Young stated in the first edition of his General Astronomy that the solar parallax is very nearly 8″.80. Twelve years has not changed the value.

Duplicity of τ Tauri.—Professor G. W. Hough in *Astronomical Journal*, No. 474, states that the fourth magnitude star τ Tauri probably has a close companion of the ninth magnitude, the position angle being north preceding and the distance from 0″.15 to 0″.4. He infers this from an observation of an emersion of the star from behind the disc of the Moon, Oct. 21, 1899, when the star reappeared first as a star of the ninth magnitude and after an interval of rather more than one second flashed out in full brightness. He examined the star on one good night with the 18½-inch refractor of Dearborn Observatory, but failed to see the companion.

To Observe the Solar Eclipse in Africa.—On Jan. 15, Mr. Percival Lowell, of Lowell Observatory, Flagstaff, Arizona, and Professor David P. Todd, of Amherst College Observatory, left in the *St. Paul*, for Africa to observe the total solar Eclipse of May 28, 1900. Mr. Lowell's many friends will be glad to learn of the improved condition of his health which allows him to undertake such a sea voyage. After a fortnight in London they will go to Paris, Nice, Marseilles, and perhaps to Rome and Milan. Then they sail for northern Africa to find in Algeria or in Tripoli some suitable point in the path of totality for the observations of the eclipse desired.

The British Astronomical Association Expedition to Observe the Total Solar Eclipse.—We have just received information regarding the proposed expedition of the British Astronomical Association to observe the total solar eclipse of May 28, 1900, in Spain and Algeria, northern Africa. An extract from the circular received from London will interest some American readers:—

"Subject to a sufficient number of passages being actually taken before Janu-

ary 31, the following arrangements have been made for the proposed expedition to Spain and Algeria.

The Royal Mail Steamer, "Tagus," (5,545 tons, 7,000 H. P.) or a sister vessel, will be engaged for the exclusive use of the Members of the British Astronomical Association and friends introduced by them, and will start from Southampton at 6 P. M. on Friday, May 18, and the following itinerary will be adopted:—

Leave Southampton	6 P. M.	Friday	18th May.
Arrive Cadiz	6 A. M.	Tuesday	22d "
Leave "	8 A. M.	"	" "
Arrive Alicante	noon	Wednesday	23rd "
Leave "	4 P. M.	"	" "
Arrive Algiers	6 A. M.	Thursday	24th "
Leave "	6 P. M.	Tuesday	29th "
Arrive Alicante	6 A. M.	Wednesday	30th "
Leave "	9 A. M.	"	" "
Arrive Gibraltar	7 A. M.	Thursday	31st "
Leave "	noon	"	" "
Arrive Lisbon	10 A. M.	Friday	1st June
Leave "	7 P. M.	"	" "
Arrive Southampton	7 A. M.	Monday	4th "

It is expected that the Members of the Association will divide themselves into three pricipal groups:—

1st. Those observing the Eclipse in the interior of Spain.
2nd. " " " " at Alicante or neighborhood.
3rd. " " " " in Algeria, where the ship will act as an Hotel for all those who wish to use it in that capacity.

The first party will, it is expected, break up into two chief sections—those who will alight at Cadiz and rejoin the ship at Alicante, and those who, alighting also at Cadiz, will rejoin the ship at Gibralter."

The Leonids in India.—Miss Moulton's report of observations of the Leonids and the Andromedes is full and interesting. We regret that we have not space for it all and the chart kindly furnished. The following extracts are made:

"On the night of the 14th and morning of the 15th the record is as follows:

Time.	Meteors.	Leonids.
1:00–3:30	29	10
3:30–3:50	9	7
3:50–4:5	17	9
4:05–4:20	13	6
4:20–4:35	20	11
4:35–4:45	23	11
4:45–5:	24	8
5: –5:15	14	7
5:15–5:20	20	11
5:30–5:37	10	4
	Total 179	of which 84

I watched from 11 till 5:45. The bright Moon made much difference with the number seen, undoubtedly. At 2:35 was a bright fire ball, leaving a trail of greenish yellow light behind' and at 5:01 there were two more like it.

On Monday, the 27th, I watched for Andromedes. This is the result:

	Meteors.		Andromedes.
8:30– 9:15	13	of which	5
9:15–10:10	12		3
10:10–10:40	6		1
10:40–11:20	14		1
11:20–11:40	12		3
	Total 57	of which	13 were Andromedes.

On Tuesday, Nov. 28:

8:30– 9:15	15		1
9:15–10:05	11		1
10:05–10:30	10		1
	36	of which	3 were Andromedes.

MARY ETTA MOULTON.

WAI, SATARA DISTRICT, India, Dec. 7, 1899.

Density of Variable Stars of the Algol Type.—The last number of the *Astrophysical Journal*, Dec., 1899, contains two very interesting brief articles on this subject. Both writers, Mr. Alexander Roberts, of Lovedale, South Africa, and Mr. Henry Norris Russell, of Princeton University, attempt to obtain, from the data of the light variations of the stars, maximum limits for the densities of the stars as compared with our Sun. The Algol Variables are assumed to be exceedingly close double stars whose components eclipse each other at regular intervals. Mr. Roberts finds the densities of the two components separately using the formulae

$$\text{Density of (1)} = \frac{(0.0092)^3}{p^3\, t^2}\left(\frac{m_1}{m_1 + m_2}\right);$$

$$\text{Density of (2)} = \frac{(0.0092)^3}{q^3\, t^2}\left(\frac{m_2}{m_1 + m_2}\right);$$

in which t is the periodic time in years, m_1 and m_2 are the masses of the components, and pr and qr are their respective diameters, r being the semi-major axis of the orbit. Since $\frac{m_1}{m_1 + m_2}$ and $\frac{m_2}{m_1 + m_2}$ must always be less than unity, practical upper limits for the densities are given by the expressions

$$d_1 = \frac{(0.0092)^3}{p^3\, t^2} \text{ and } d_2 = \frac{(0.0092)^3}{q^3\, t^2}.$$

The constant 0.0092 is not explained by the writer but we assume it to be the diameter of the Sun in astronomical units.

Treating four southern stars which he has had especially under observation Mr. Roberts obtains the following results:

	Period. t d	h	m	Duration of Minimum. h	m	p	q	d_1	d_2
X Carinæ	0	13	00	6	30	0.71	0.71	0.25	0.25
S Velorum	5	22	24	14	50	0.17	0.46	0.61	0.03
Lal. 5861	0	14	32	7	16	1.0	1.0	0.27	0.27
RS Sagitarii	2	9	59	{ 10	40	0.48	0.44	0.16	0.21
				{ 7	00				

If the masses of the two components in each were assumed to be equal, then $\frac{m_1}{m_1 + m_2}$ and $\frac{m_2}{m_1 + m_2}$ would each be one-half and each of the densities given above would be divided by two. The average density of these four stars would then be 0.13 or only one-eighth that of the Sun.

Mr. Russell attempts only to find the average density of each system, but by a different method reaches very similar results. He finds as an expression of the upper limit of density

$$\rho \leq \frac{3K}{\pi t^2 \sin^3 \frac{\pi d}{t}}$$

in which t is the period of the variability, d the duration of light variation, and $\frac{3K}{\pi}$ is found from the density of Earth (5.53) to be 44.1. The results for 17 stars are as follows:

No. in Chandler's Catalogue.	Name.	t in hours.	d in hours.	Limit of Density.
320	U Cephei	59.82	10.	0.098
1090	B Persei	68.81	9.15	0.139
1411	λ Tauri	94.87	10.	0.142
2610	R Canis Maj.	27.26	5.	0.366
3055	χ Carinæ	13.00	6.5	0.261
3109	S Cancri	227.63	21.5	0.035
3416	S Velorum	142.40	15.2	0.061
5374	δ Libræ	55 85	12.	0.058
5484	U Coronæ	82.85	9.75	0.137
5949	R Aræ	106.21	10.3	0.145
6189	U Ophiuchi	20.13	5.1	0.298
6442	Z Herculis	95.82	5.3	0.728
6546	RS Sagittarii	57.93	10.4	0 086
7399	W Delphini	115.35	10.	0.170
7488	Y Cygni	71.90	8.	0.212
	DM. + 12°3557	21.35	5.	0.320
	B. D. + 45°3063	109.75	13.	0.076

The Corona of the Sun Visible Without an Eclipse.—From an article elsewhere published in this number it will be seen that Professor E. Miller, of the University of Kansas, has been trying to make visual observations of the Corona of the Sun without the aid of the Moon at time of total solar eclipse. He feels quite sure that he has succeeded in the attempt, and definitely and clearly states how it was done. He would have made more observations if it had been possible then or since for him to do so. We are sure, from correspondence and from the language of the article, that he feels the need of more evidence to substantiate the large and wonderful claim that he makes, than has yet been secured. We are also sure that our readers will say, that there must be some mistake about this single observation, and some cause for the peculiar phenomenon which he saw, that is yet unexplained and that the picture is not one of the Corona, although it looks somewhat like that which should appear in the polar regions of the Sun. We are anxious that Professor Miller shall have the full benefit of the earliest announcement possible to him, for any such notable discovery as it *may be possible* to make in this way. We urge him to try again and so learn, by varied trials, whether he can see the Corona in this way beyond a reasonable doubt.

Modern Astronomy.—Messrs. Wm. Wesley and Son, scientific booksellers and publishers, 28 Essex Street, London, England, have recently issued a scientific and natural history book circular (No. 135), which deals with modern astronomy in a helpful way. It is nothing less than a classified catalogue of books and pamphlets on modern astronomy. It embraces the literature on the subject since 1800, including the libraries of Edwin Dunkin, Rev. A. Freeman, J. R. Hind, A. Marth and E. J. Stone. The classification of the catalogue appears under 35 heads making the reference to any astronomical theme very easy and certain. Under these heads are classified 2240 books and pamphlets treating of subjects comprising the whole range of modern astronomy during the 19th century. Under each separate head the authors' names are alphabetically arranged and printed in heavy-faced type so as to be very easily caught by the eye as the index list is scanned. We do not know of any catalogue compilation in the interest of general astronomy that is so complete and useful generally, as this new Wesley catalogue, for the period of time it covers.

Honor for Dr. Wm. R. Brooks.—We have failed to notice, as promptly as we should have done, the deserved honor which has again been conferred on Dr. William R. Brooks of Smith Observatory, Geneva, N. Y. He has recently received the Lalande prize awarded by the Paris Academy of Sciences. In the language of the award it is bestowed "for numerous and brilliant astronomical discoveries." American astronomers are having their share of honors dispensed by the foreign learned societies. Congratulations to Dr. Brooks.

Occultations During the Eclipse of Dec. 16, 1899.—Below are given the local mean times of disappearance of a number of faint stars, observed with the twenty-inch refractor of the Chamberlin Observatory, the magnifying power being 200. The position angles are from the north point of the limb toward the east. As the Observatory has not received the European list no attempt has been made to identify the stars. The position of the Observatory is given in the American Ephemeris, under the heading Denver.

Magnitude.	Position Angle. °	Mean Time. h	m	s	Notes.
9.5	80 or 90	6	0	58.9	Good.
10.5	90	6	2	49.4	Poor.
7	70	6	7	32.6	Good.
10	70	6	16	22 9	Pretty good.
9.5	75	6	27	1.4	
11	65	6	27	46.4	Rather poor.
10	65	6	29	1 9	Good.
10	55 ±	6	29	5.8	Good.
11	53	6	34	44.4	
10.5		6	36	22.6	
10.5	0	6	40	25.3	Uncertain.
10.5	60	6	54	0.8	Time late, from faintness of star.
10	45	6	56	35.2	Pretty good.
10.5	65	7	3	36.3	Pretty good.
8	75	7	24	10.8	Bad, because of brightness of Moon.
8	15	7	32	21.0	Pretty good.

HERBERT A. HOWE.

UNIVERSITY PARK, Colorado.

Solar Eclipse, May 28, 1900.—Phases for Latitude 37° 30′ N. Longitude, 94° 16′ W ($6^h\ 17^m\ 4^s$), which point is near Lamar, Barton Co., Mo.

Eclipse begins	$6^h\ 37^m\ 19^s$	Central Time. A. M.
Greatest Observation	$7^h\ 39^m\ 36^s$	
Eclipse ends	$8^h\ 48^m\ 24^s$	
Duration	$2^h\ 11^m\ 5^s$	

Nearest approach of centres of Sun and Moon 410″.
Magnitude .7878. Sun's diameter unity.

POSITION ANGLE.

First Contact	25°	South of West.
Last Contact	49′ 28″	North of East.

On the Sun's disc.

Calculation by ORRIN E. HARMON.

LIBERAL, Barton Co., Mo.

Staff of the United States Naval Observatory.—The following changes in the personnel of the Observatory have taken place during the fiscal year:

Capt. Charles H. Davis, U. S. N., reported for duty as superintendent on November 1, 1898, relieving Commodore Robert L. Pythian, U. S. N., who was detached on that date.

Lieut. Charles C. Marsh, U. S. N., reported for duty on January 26 and was assigned to the department of nautical instruments, but was detached on January 30, 1899.

Lieut. A. N. Mayer, U. S. N., in charge of the departments of nautical instruments and chronometers and time service, reported for duty on September 16, 1898, and was detached on June 20, 1899.

Lieut. Ben W. Hodges, U. S. N., reported for duty on June 28, 1899, and was assigned to the departments of nautical instruments and chronometers and time service.

Computer M. E. Porter was detached from the transit circle and sent to the time service on July 15, 1898.

Prof. John R. Eastman was retired for age July 29, 1898, but on account of the Spanish war he remained on duty at the Observatory until October 12, 1898. He was originally appointed as aid on November 7, 1862, and was promoted to be professor of mathematics, United States Navy, February 17, 1865.

Mr. Aaron N. Skinner was promoted from assistant astronomer to professor of mathematics, United States Navy, on July 30, 1898. He has served continuously at the Observatory since March 28, 1870, when he was appointed an aid.

Mr. John N. James, electrician, resigned July 31, 1898.

Mr. R. H. Charles was appointed to be electrician August 1, 1898, vice Mr. John N. James, resigned. Mr. Charles was originally appointed as engineer February 17, 1898.

Mr. Frank B. Littell was promoted from computer to assistant astronomer on August 6, 1898.

Computer W. S. Eichelberger was transferred from the Nautical Almanac Office to the Observatory on August 15, 1898.

Mr. George H. Peters was appointed photographer on August 15, 1898, vice Charles T. Fellows, deceased.

Mr. William F. Gardner, instrument maker, died December 11, 1898. He was first employed in the Observatory on September 8, 1864, and was promoted to be instrument maker on November 1, 1866.

Mr. J. W. Davison, employed in the library, left the Observatory on February 3, 1899, and his place was supplied by Kenneth B Turner, formerly employed in the Treasury Department, with whom he had exchanged positions.

Professor T. J J. See reported for duty at the Observatory on March 2, 1899.

Professor H. M. Paul was detached from the Observatory on March 3, 1899.

Mr H. C. Cleve reported for duty as instrument maker on March 7, 1899, vice William F. Gardner, deceased.

Professor Edgar Frisby, U. S. N., was retired for age May 22, 1899. He was originally appointed as an aid on June 22, 1868, and was promoted to be professor of mathematics, United States Navy, June 11, 1878.

Rapid Change on the Surface of the Sun.—Caroline E. Furness in charge of the Observatory at Vassar College, Poughkeepsie, New York, was examining the surface of the Sun, with the telescope, Jan. 22, at about 3 o'clock in the afternoon, and noticed an interesting change going on at one point in the surface. When first looked at the solar surface was everywhere clear of spots. Fifteen minutes later, a very small spot was seen near the central region. The image of the Sun was thrown upon a screen and made about fifteen inches in diameter. The spot then appeared like a pin head. While watching it closely a second fainter one appeared near it, and presently two or three attendant darkenings which looked very much like the ordinary nodules, except that they were dark enough to stand out quite conspicuously against the mottled disc of the Sun. In ten minutes these dark bodies had faded so as to be scarcely visible, and only the first spot remained. As the Sun was low the observations could not be continued longer, and the next morning there was no trace of any disturbance.

It is true that important changes in the solar surfaces are contantly going on, yet it is somewhat rare to notice those that are so peculiar and so rapid.

Beman and Smith's Plane and Solid Geometry.—This book is a revision of one published by the same authors in 1895. The distinctive features of it are the retention of a minimum of formal proofs as models, and a maximum of unsolved and unproved propositions as exercises. The authors are fully aware of the late strong tendency to break away from the formal proofs of Euclid and Legendre, and to substitute for them methods of work calculated to lead the student to independent discovery. These authors do not believe that the best results in scholarship are to be gained in this way, but rather, that the student should be well started in the ways of geometrical thinking, by the use of good models of reasoning and some exercise in applying mathematical language to geometrical figures. When the student has some acquaintance these ways of elementary thinking, then the teacher may safely begin to exercise or tax the learner gradually and progressively on the side of training which is sometimes called invention or discovery.

In this we think these authors judge wisely. We believe they are right.

The ideas of modern geometry that simplify the ancient methods find deserved place in this revision. The free use of various kinds of symbols to abbreviate definitions and proofs is in full keeping with modern ways that are in

general favor. The manifest gain in this way of writing is the advantage in holding the attention of the student, while he is trying to master a given course of reasoning, or to gain knowledge of an unfamiliar principle or concept. Clear and concise expression has great value if it be not so brief as to be ambiguous. The eminent and scholarly Loomis of Yale, years ago, used to call his students back to demonstrations in geometry a second time often, and say "now, have given those proofs in the best way possible! Try again."

As far as we have had opportunity to examine this book, it appears to be work very well done. It is expected that the publishers will do their work well, for Messrs. Ginn & Company always do their part admirably.

Holden's Elementary Astronomy.—This new book is published by Messrs. Henry Holt & Company, and is one volume in the elementary course of the American Science series which is being issued by the same publishers. It is a beginner's text-book and contains 446 pages with ample illustration, which is neat, well-chosen and not obtrusive. The book is a condensation of two others written by Professors Newcomb and Holden about twenty years ago for this same science series. Though a condensation in matter, it is entirely re-written and many new illustrations added which makes the book to well represent the state of the present advancement of astronomy in phases most useful for elemental study. We are pleased to notice how aptly and well the author has presented in illustration and happy expression the more difficult topics that must receive some attention even in an elementary text-book. One illustration of this is a cut representing the fall of rain in which a man, a horse and a train of cars are running at different rates of speed. The drops appear to be falling vertically over adjacent houses, obliquely against the man, and more and more so against the horse and the more rapidly moving train. It is a most delicate art to illustrate well, especially if the theme is a hard one to comprehend in the most favorable light that may be shed upon it. This is certainly true in the case of the aberration of light.

Another excellent illustration is the two page cut of the Moon with numbers and names on the picture, and outside on the same page, are found 189 names of objects referred to and located on the map in the proper quadrant to which each one belongs. This scheme is an admirable key to guide anyone in elementry stuy of the lunar surface.

The later ways of presenting the themes of elementary astronomy by what is called the "laboratory" or the inductive method has reeeived some attention in this new book. It is done by means of lists of review questions, and cuts of simple apparatus which may be made easily by any one. This kind of exercise is made quite prominent and the teacher is expected to use his own judgment in emphasizing this part of the training exercise. From a perusal of the full and carefully written introduction, one will readily understand how important the author deems this kind of work. Professor Holden has prepared a first rate text-book and the publishers have done their part well. Teachers will examine it with interest and profit.

Scientific Thought of the Nineteenth Century is the title of an address, delivered before the Connecticut Academy of Arts and Sciences October 11, 1899, by Wm. North Rice. The purpose of the address was to call attention to a "single, broad, general aspect of the intellectual history of our age." In brief, it was to show how largely general ideas which make a distinction between the

scientific and unscientific view of nature have wrought during the nineteenth century.

The first of these ideas is the extension of the universe in space. The unscientific mind looks upon the celestial bodies as belonging to the Earth, and as relatively small and near to it. The scientific mind knows that the stellar universe stretches away into illimitable space which outreaches all finite power or imagination to measure it.

Another idea is the extension of the universe in time. The unscientific mind does not know that the universe has a history. To such thought it is only chaos. To the scientific mind the universe is a cosmos. Its forces are not discordant however much they appear so. Polytheism is not a part of religion, for the scientific mind knows that this universe is dominated by a supreme unity, imminent in all things in time and space.

A third idea is the unity of the universe. To the unscientific mind the processes of nature are thought of as acting independently and often in discordant way, To the scientific mind the boundless complexity is pervaded by one system of law, intelligible, formulable throughout all its measureless extension in space and time.

The extension of the universe in space had its growth mainly in earlier times. The Greek geometers learned the approximate size of the Earth and the distance of the Moon. The Copernican system of astronomy as modified by Kepler gave the true idea of the solar system; the discovery of Neptune greatly increased its size, and the known distances of a few stars show the vast magnitude of the stellar universe as it is now approximately measured.

The extension of the universe in time was known to some extent in the time of Pythagorus from a study of the changes in the crust of the Earth, but Hutton's Theory of the Earth, in an important sense marked the beginning of modern theorizing as to the time from the study of Geology.

In this century is found the chief development of astronomy in regard to the history of the solar system. The work of Laplace, Kant, Swedenborg and Newton laid the foundation and the building thereupon has been large and amazingly rapid.

The author then speaks of spectrum analysis, conservation of energy, modern chemical philosophy and finally lauds lavishly the idea of evolution as the greatest intellectual achievemnt of our age. In one of his rhetorical flights, he sees "the author of that sublime Hebrew psalm of Creation, preserved to us in the first chapter of Genesis" as "evolutionist in his way," because he says "let the earth bring forth, let the waters bring forth." The idea, he thinks, is growth and not manufacture.

In the last paragraphs of the address the author professedly goes outside the realm of science to speak of Theology, the Church and the immanence of God. He fairly speaks of the influence of science on religious thought in such a way as not to disturb Christian faith in a real revelation. But when he implies the existence of such an imminent "Intelligence" in nature that there is no room for the "Carpenter God" of the old Theology as he chose to call Christ, then our instructor in Theology is assuming much that he evidently does know. That is unscientinc assumption. That is begging the question more than Darwin and Huxley ever did when they honestly thought they had proved the origin of life in matter. Mr. Rice should review his logic before he makes another attempt of this kind.

Variables.—The following variables, though of small magnitude, were found with a four inch telescope without circles by the aid of the charts published in POPULAR ASTRONOMY.

The period of W Lyræ* is unknown and its variations seem to be of an irregular nature.

Oct. 11th, 1899.	W Lyræ is of 12th mag.	Nov. 29th, 1899.	About of 9 mag.
22d	It is of 10th mag.	30th	Do.
23d	Do.	Dec. 1st	Do.
28th	It is about 9th mag.	2d	Do.
31st	Of 10th mag.	3d	Do.
Nov. 1st	Do.	5th	Do.
4th	Of 9th mag.	6th	Do.
6th	Do.	17th, 18th and 19th it was fully equal to adjacent star of 8.6 mag.	
21st	Nearly 8.6 mag.		
22d	Slightly decreased.		

After this it was hidden from view at dusk by neighboring buildings but it is to be hoped that other observers traced its variations to a later date.

Madam Ceraski's† new Algol variable in Cygnus was observed as follows, the comparison stars being those so conveniently furnished by Mr. J. A. Parkhurst:

Nov. 2d, 1899.	Barely visible in a high power.	Dec. 20th	Do.
		21st	Do.
4th	Nearly of 8.6 mag.	22d	Nearly of 8.6 mag.
6th	Do.	23d	Do.
21st	Do.	24th	Of about 9 mag.
22d	Brighter than 9.6 mag. perhaps about 9th.	25th	Do.
		26th, 6:30 P. M.	Invisible in a low power but in a high power it seems to be scarcely 12th mag.
29th	Midway between the comparison stars of 8.6 and 9.6 mag.		
30th	Do.	27th, 7 P. M.	It is very nearly of 8 6 mag.
Dec. 1st	Do.		
2d	Do.	Jan. 3d, 1900.	It is of 9th mag.
3d	Of 9 6 mag.	4th	Do. Night hazy.
5th	Brighter than 9 6	5th	Do. Do.
17th	Of 9.6 mag.	8th	Of about 10th mag.
19th	Brighter than 9.6.		

SAN FRANCISCO, January, 1900. ROSE O'HALLORAN.

PUBLISHER'S NOTICES.

Contributors are asked to prepare copy carefully, and write *all proper names very plainly*. If other language than the English is used to any considerable extent it should be type-written. Manuscript to be returned should be accompanied by postage for that purpose.

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All correspondence and all remittances should be sent to

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* The period of W Lyræ is quite well known, and is more regular than the average long period variable. Since its discovery by Anderson in 1896, it has been observed at least once in every week by either Mr. P. S. Yendell, Zaccheus Daniel or J. A. Parkhurt. For their results see *Astronomical Journal* No. 388, 397, 412, 426, 434, 456, 458, 465, 473. Dr. Hartwig gives the period as 200 days; the result from 3 maxima and 5 minima observed at Marengo is 197 days.

† In case of Algol-type variables, like the above Ceraski star, the time of observation should be given to the hour and minute.